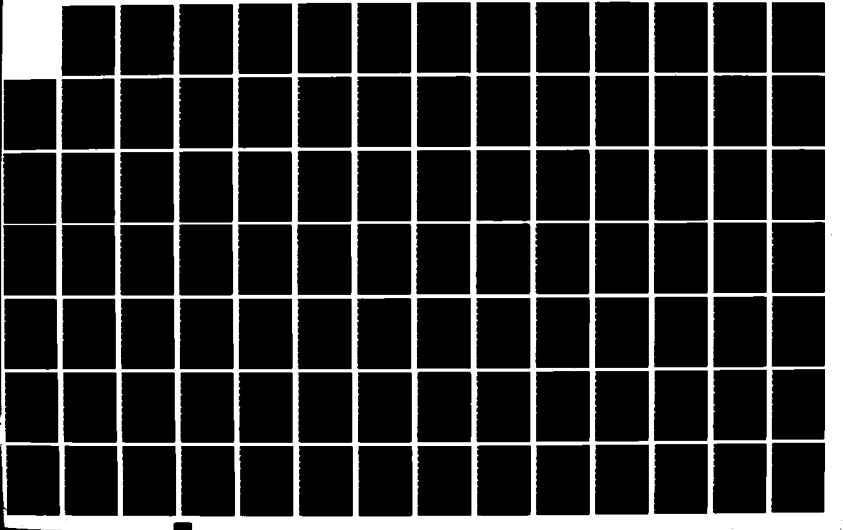
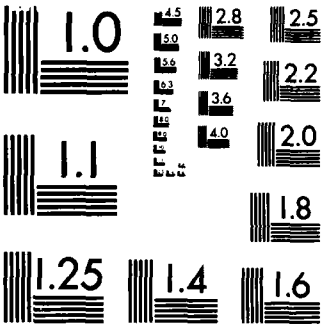
AD-A161 025 EXPERT SYSTEMS FOR CIVILIAN PESSONNEL ADMINISTRATION 1/2
(U) OFFICE OF THE DIRECTOR OF CIVILIAN PERSONNEL (ARMY)
WASHINGTON DC PLANNING AND EVALUATION OFFICE
UNCLASSIFIED L D MARTINDALE 01 JUL 85 F/G 9/2 NL





(12)

EXPERT SYSTEMS for CIVILIAN PERSONNEL ADMINISTRATION

A Report on
A Secretary of the Army Research and Study Fellowship
Prepared by
Loren D. Martindale, Fellowship Recipient
1 July 1985

Office of the Director of Civilian
Personnel, Planning and Evaluation Office
Washington, DC 20310

TABLE OF CONTENTS

Preface 1
1. What Are Expert Systems? 3
2. How Expert Systems Work 7
3. How Expert Systems Are Built 11
4. Expert System Demonstration Module 13
5. Where Expert Systems Could Be Used In CPO 21
6. Strategies For Use 25
7. Hypotheses For Expert Systems Use In CPO 29
8. A Prototype System 33
9. Alternatives For Development 39
10. Project Office 45
11. Equipment Needs 51
12. The Test Installation 53
13. Time-Frames 55
14. Evaluation of Expert Systems 57
15. Army's Experts 61
16. Potential for Cost Savings 65
17. Impact On Personnelists 69
18. An Experiment 73

APPENDIXES

A. References
B. Equipment Used On This Project
C. Time Schedule For Prototype Development
D. Cost Analysis - Salaries & Potential For Savings
E. Demonstration Module Files
F. Source Code For Briefing
G. Severin Johnson's Report
H. Army's Experts in Functional Specialties (original report)
I. Critical Issues Questionnaire
J. Contacts Providing Information/Consultation
K. Scope Of Work Statement
L. Executive Summary

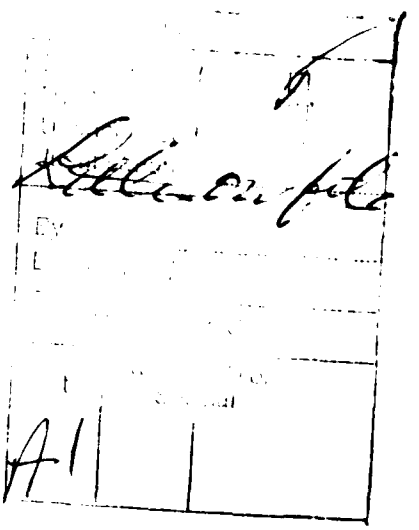
FIGURES

1. Flow chart for Wage Grade demo module of expert system
2. Estimated number of rules for classifying Budget Analyst Jobs
3. Estimated number of rules required to classify jobs in selected occupations
4. Organizational chart depicting the recommended placement of the project office
5. Milestones for prototype development

TABLES

1. Test results of demonstration module vs. human classifier
2. Summary of data concerning Army experts

The findings, recommendations, and opinions expressed in this report are those of the author and should not be construed as an official Department of the Army policy or position unless so designated by other documentation.



TO MY SONS

Geoff, Stan and Brad

PREFACE

Much hoopla has been made of computers in recent years. Computer usage is both fascinating and intimidating. When the microcomputer revolution began in the mid-seventies, some of us began tinkering with this new technology as a hobby. As these small systems became more powerful and easy to use, they started showing up in offices, first as cheap word processors, then as tools to do more challenging and analytical work. We, in the personnel administration business became more aware of what computers could offer in helping us manage the tremendous amount of information that we deal with on a daily basis. We began to question the versatility and functionality of standard systems such as SCIPMIS, CIVPERCINS, COEMIS, etc. These "accounting" systems are harbored in the depths of the DMIS, tended by minions who loath to share the secrets of their profession, and the tools used for these data base management "wonders".

We began to see that computers could, and should do more than just print out standard reports that all too frequently required manual juggling of the data after we got the printout. We began to demand more useful and powerful systems, systems with memory of what had been processed, not just the current state of an employee's record. This information is essential, since we are monthly, daily, even hourly asked to provide information to others about events such as "how many black women were promoted during the last quarter, what is the grade break out of those promoted, and how does that compare with other groups' promotions?". Questions such as these require manual searching of records, since our standard systems can only tell us how many black women we have, and for the enterprising sleuth on some of our systems, how many were promoted during the last quarter. Most of us are not knowledgeable enough of our systems to know that the latter part just might be available with a lot of work on the part of a programmer. Most of us use the manual method of answering complex questions about personnel action statistics. And for good reason!

Some of us in the personnel business have begun to see that powerful computer systems are available for modest cost, and are automating our offices. We all seem to be going different directions, but at least some of us are automating out of self defense. There is a cry for standardized systems, but no one dare hold back the movers for fear of being asked to provide a standard solution for all. And have it next week since we all know the outcome of "real soon now" by experience.

There are some new uses of computers about which this report has

been prepared. These uses have emerged from artificial intelligence research which commenced in the mid-sixties and are known as expert systems. I began to get interested in expert systems in mid-1983. After reading all I could lay my hands on about the subject, I began to realize that expert systems technology could be applied to the field of personnel administration. I submitted an application for a Secretary of the Army Research and Study Fellowship (SARSF), which was subsequently approved, and I began a six month study of applying expert systems to the field of personnel administration. This report is the results of my investigation.

There are many who deserve thanks for assistance and support to me in carrying out this project, only a few of whom I have room to mention. My family for bearing with my being away for six months; Jim Clark, my XO at YPG for helping to get the application for the SARSF off the installation; Ray Sumser, for his vision in recognizing a potential idea when he saw it, and putting his power behind approval of the SARSF; Conrad Lacy and others on the DA staff for their help with information and assistance during the study; Joe Carlson and his staff, San Francisco Field Office for providing the environment in which to conduct the study; Severin Johnson, CPO, Oakland Army Base, for able assistance when temporarily detailed to this project; the many personnelists who contributed information when contacted; and the staff of the Yuma Proving Ground Civilian Personnel Office for carrying on with our personnel program while I was away on this project.

There is nothing more powerful than an idea whose time has come.
- Victor Hugo -

1 WHAT ARE EXPERT SYSTEMS?

This research project dealt with a study of the application of expert systems technology to the civilian personnel administration functions in the Department of Army. Expert systems technology is a relatively new technique, although the idea of the concept has been around at least since the first computer was designed and built. In science fiction literature, writers have used their lively imaginations to spin tails about the future in which expert systems are a given, and aren't even called by a name at all. In their accepted fashion, computers and robots posses "thinking" capability without question. In spite of the computer's awesome power to manipulate data, attempts to program it to simulate human brain capability remained allusive for many years.

In the 1960's computer scientists began to place a heavy emphasis on artificial intelligence (AI) usage of computers. At universities such as Carnegie-Mellon, MIT, Stanford, UC Berkeley, Rutgers and others, and in company research departments such as Rand, Xerox, Bolt, Baranak and Newman, SRI International, etc., AI projects were undertaken. These projects covered such areas as linguistics, robotics, perception, reasoning, and other cognitive science areas. One general area that began to show considerable promise in terms of practical applications was expert systems.

Expert systems are computer programs that tackle complex problems which require a specialist or expert to solve, and provides solutions to the problems using a computer model of the human expert's reasoning techniques. The solution to the problem provided by the expert system is the same one that the human expert would have reached. In this section of the report, I will review several expert systems that have been developed. This will give the reader an understanding of what expert systems are, and will give credence to the idea that they actually work. I will not attempt to go into detail as to how they do what they do. Such a subject is beyond the scope of this research project, and in many ways beyond my capability to explain. The technically inquisitive reader may refer to Appendix A as a starting point for further reading in this area. The references also contain their own references for further, in-depth reading.

MYCIN. This expert system was developed in the mid-1970's, and was designed to diagnose and prescribe treatment for infectious blood diseases. When used by a physician, the program prompts the doctor for information about the patient, results of tests conducted on specimens from the patient, and observations made of

the patient by the physician. As the questioning by MYCIN progresses with responses from the doctor, the program uses expert knowledge and reasoning techniques to infer a diagnosis. After a diagnosis is rendered, MYCIN proceeds to query for additional information so that a therapy recommendation can be made. MYCIN will then prescribe the drugs to be used to combat the diagnosed infection in the patient. This expert system has been extensively tested by medical experts. Tests have shown it to be as good as, or superior to physicians in diagnosing and prescribing treatment in the specialized domain of medical knowledge that it represents. One of the major results of the MYCIN project was a by-product called EMYCIN. This program is a framework (programming environment), or tool which is generalized in nature and application independent. It can, and has been used to develop other expert systems. One could view it as MYCIN without its specific knowledge of bacteremia. The EMYCIN system has been used to produce another well-known medical application called PUFF, which is concerned with pulmonary functions.

There have been some other notable expert systems developed for medical related knowledge domains such as CADUCEUS and INTERNIST which both work in the area of internal medicine diagnosis and treatment, and CASNET which is specific for glaucoma diagnosis and therapy.

PROSPECTOR. This system works in the knowledge domain of mineral exploration. Specific types of minerals for which models have been developed for PROSPECTOR are sulfide, carbonate lead/zinc, porphyry copper, nickel sulfide, and uranium. The system can be used by geologists and others who know the geological terms used by the system to query for information from the user. Much of the query process uses requests for confidence measures from the user. Thus a question such as "To what degree do you believe that the target area lies in a greenstone belt?" The user must supply a number from 0 to 5 representing his confidence that this is true. Obviously, one has to know what a greenstone belt is, and be able to supply some assessment of the area under consideration as to whether it is one or not. PROSPECTOR will also accept volunteered information from the user. Thus it offers another dimension to a session other than only querying for responses from the user. This is termed a mixed initiative mode and gives the user an additional means of control over a session with the expert system. At the conclusion of the session with PROSPECTOR, the system displays an index showing the favorableness of the mineral being present in the target area. PROSPECTOR has been credited with finding a molybdenum deposit whose ultimate value will probably exceed $100 million.

R1. This is an expert system presently in real world use by Digital Equipment Corporation which configures VAX computers. VAX computers, as well as most mini and main frame systems, are put together from a wide range of sub-assemblies. These sub-assemblies can be such things as different back-planes (a kind of socket board that accepts plug-in boards), power supplies, memory boards, central processor boards, boards to handle input and

output to other devices such as disk drives and terminals, and other such things. A VAX computer can be configured in a multitude of different ways. When a customer purchases a VAX computer, it is configured to meet the customer's specific needs. Given the number of parts and sub-assemblies involved, it is not readily apparent, without considerable expertise, to insure all of the necessary pieces have been ordered, will work together, and are shipped so that the product can be assembled to meet the needs of the customer. DEC used to use highly trained technicians to review purchase orders and shipping documents to insure all parts were included, and the system was configured properly. This job is now performed by R1. R1 also produces a set of diagrams depicting the spatial relationships between the components.

DENDRAL. This system's expertise lies in the knowledge domain of chemicals. DENDRAL accepts queries from users to apply expert decisions about the plausible structures of an unknown compound. The system uses data supplied by the user which is mass spectrographic, nuclear magnetic resonance and other chemical experiment data and applies a large knowledge base, plus an efficient inferencing technique to draw conclusions. DENDRAL, which is nearing two decades of existence, was one of the earliest expert systems developed for a practical problem. It is currently used by hundreds of international users daily for chemical structures analysis.

While there are a number of other expert systems in existence, and more being developed, the above examples will give some indication of what expert systems are capable of doing. Recently companies have been exploring new uses such as systems that do loan analysis for lending institutions. Such systems may eventually replace experts known as loan officers. Expert systems to help fly the space shuttle, diagnose problems on satellites, assist mechanics repairing diesel-electric locomotives, and a wide variety of other knowledge domains are either under development or already exist.

2 HOW EXPERT SYSTEMS WORK

As mentioned earlier, it is not within the scope of this project to thoroughly explain to the casual reader how expert systems do what they do. Some explanation of how they operate is necessary in order to report on potential tools that might be used by a knowledge engineer in building a personnel administration expert system.

As opposed to conventional procedural programming, in which specific procedures are laid out in the program to control its flow, AI programming uses descriptive techniques in which solutions to problems are described, not prescribed. Lest this all sound like a bunch of high-tech gobbledygook, perhaps an example will help to clarify the differences.

Suppose a program is being written to solve the problem of finding a name in a data base of several hundred names. The programmer, using a conventional procedural language would write a procedure that would ask the user for the name being sought. When the name is input, the program has a specific procedure that says, assign the input name to a variable, compare this variable with each name variable in the data base, if a match is found, select the entire record associated with that name and print it out on the screen, if a match is not found print the message "Name not found" on the screen. In an AI programming language such as PROLOG, the programmer describes the solution, and the programming language solves the problem. For example, on the same problem, the programmer would write a description of the solution that says the "solution looks like this", and the programming language would solve the problem.

Expert systems have been modeled on several different kinds of inferencing techniques. Some of these techniques will be discussed.

Production rules are necessary for most expert systems operation. A production rule takes the form of IF - THEN construct. The IF portion of the rule is tested by the program based on facts known to the system. If this test is found to be true, the THEN portion of the rule is asserted. When this occurs, it is known as a rule firing. An example of an IF - THEN rule might look like this (in English):

IF the employee is required to have contact with Members of Congress, AND
IF the contacts are for the purpose of presenting major portions of the agency's budget, AND

IF these contacts occur at regular intervals

THEN assign a value of 110 points for CONTACTS with a certainty factor of .85

In this example (which might be a rule in classifying a Budget Analyst position), the rule is fired if, and only if all three IF clauses are true. Other rules may have lead up to this rule, for example, a production rule might have been fired to determine what is meant by "major portions of an agency's budget". As can be seen in this example, a certainty factor can be assigned to a rule. This is important to many rule based expert systems, since it is frequently desirable to combine several certainty factors before actually making a decision.

Another technique that is used in expert systems is a method of representing knowledge as objects. These objects are usually called frames, and have unique characteristics. A frame can have many slots as they are called which serve to describe and link the frame to other frames. An example of a frame is:

POSITION, which may have slots which describe it such as Title, Series, Grade, Knowledge Required, Supervisory Controls, Incumbent, etc. A frame slot can be filled with facts, for example 11 for grade, and can be linked to other frames by common slots, for example an incumbent's name could occupy a slot in another frame called SUPERVISOR. A slot can also be occupied by a procedure such as a procedure to calculate age for the slot called AGE.

Many complex and powerful relationships can be represented by a frame based system. Many expert systems utilize both frames and production rules in combination, which provide a great deal of reasoning ability.

The ability of expert systems to draw inferences and make decisions is accomplished in the inference engine of the system. Rules, reasoning strategies and control mechanisms constitute the basis of the inference engine. For example, a control mechanism is necessary to insure the expert system knows how to start, and proceed through a decision making process, and to resolve conflicts when they arise. A reasoning strategy that uses forward chaining, or backward chaining, or a combination of both can be utilized. Forward chaining involves applying facts to rules, and as rules fire, using this new knowledge to fire other rules until the system gains enough information to draw a conclusion. Backward chaining occurs when the system chooses a hypothesis to prove, and then chains backward to gain facts that would support this hypothesis until the hypothesis is either proven or disproven. Control mechanisms are also required to optimize the search by the system to make inferences about the facts present. For example a breadth search technique causes the system to sweep across all premises in a rule before digging for greater detail about subgoals. A depth search digs into details about a particular subgoal before going on to other subgoals. As

a way of illustration, a breadth first search in the area of job classification may cause the questioning to jump from a question about knowledge to one about personal contacts, and then to supervisory controls, and back to get more information about knowledge. A depth first search would result in all questions about knowledge being gathered first before moving on to supervisory controls.

Many of the references in Appendix A cover these techniques in considerable detail, and the inquisitive reader interested in building a better foundation in techniques of knowledge representation and reasoning strategies in expert systems is encouraged to read these materials.

It would appear to me that the civilian personnel administration problem is subject to solution by use of production rules. For the most part, solutions to any problem in our business revolves around the application of rules to the problem at hand. For example, the qualifications determination on an employee utilizes rules based on the kinds, amount and quality of experience and training. Staffing specialists use published guides, some of which are very specific and prescriptive, and rules of thumb gained through experience in making qualifications determinations. These rules can be embodied in an expert system using production rule techniques of AI programming. Frame based techniques also offer advantages in linking a variety of facts about related objects (people, positions, etc.) into an integrated knowledge base. Utilization of powerful software development tools that have many of these features available will allow for the development of an expert system capable of making expert decisions about personnel matters.

3 HOW EXPERT SYSTEMS ARE BUILT

The actual development of an expert system has, in the past, been done by a very highly specialized individual known as a knowledge engineer. Knowledge engineers possesses skills and knowledges of expert systems structures, i.e. the various inferencing techniques that have been successfully utilized. They also are skilled at programming (although few actually write the code for computer programs), and have highly developed abilities in interviewing experts in other knowledge domains, and narrowing the knowledge base down to the specific rules the experts use in making decisions and judgments. The knowledge engineer constructs an expert system either through the use of an existing expert system building tool, or through directing the programming efforts of programmers who write code in a high level language (usually LISP or PROLOG). Some of the tools available for building expert systems are: EMYCIN (which was mentioned above), ROSIE, KAS, EXPERT, OPS5, RLL, HEARSAY-III, AGE, KEE and ART, to name a few.

These tools run on mini or main-frame computers. Most of them are products of large scale expert system development programs. EMYCIN resulted from the MYCIN project, HEARSAY-III from work on speech understanding systems, and KAS from the work done on PROSPECTOR. Each of these tools are proficient in specific kinds of expert systems engineering. Some attempts have been made to evaluate the capabilities of them in a comparative mode, having an identical problem being solved using each system (see Hayes-Roth, Waterman and Douglas).

There are several stages to the development of an expert system. Various publications have laid out the stages, and many recommendations for development are available. The following stages are a synthesis of these recommendations as I believe they apply in this particular application.

Stage 1. General Assessment. This involves assessing the feasibility of applying the technology to the domain of knowledge under consideration. It includes an analysis of potential cost-benefit ratios, what areas of the knowledge domain could benefit by expert systems usage, what policy or other issues need to be addressed, what resources are needed, etc. This report serves as the Stage 1 process.

Stage 2. Design and Build Prototype. This stage is an R&D effort to actually build a prototype system for the knowledge domain selected. The tool or language to be used is selected, a strategy for attacking the problem is formulated, and work begins

on developing the prototype. At this stage, several false starts may be experienced, but the purpose is to get a prototype operational for further test and development.

Stage 3. Development. Knowledge is added to the system, and experts are used to further expand on the ability of the prototype to make accurate decisions. During this stage, the goal is to insure the prototype is ready to be tested in an actual setting. The scope of the prototype may not encompass the entire knowledge domain, but the scope that has been selected must be thoroughly and completely developed.

Stage 4. Test and Validation. During this stage, the prototype is put to actual use. Its performance is closely monitored, and ideally redundant work is performed by human experts to check the validity of the system. During this stage, further development may be indicated by the results achieved in this beta test mode.

Stage 5. Implementation Planning. This stage will identify the means, methods and time schedules for putting the prototype on line for productive use.

Stage 6. Implementation. The system is designated a standard system and distributed for mandatory use by all users who are affected by its knowledge domain.

Stage 7. Maintenance and Extension. This stage is continuing in nature. All expert systems require maintenance to keep them up-to-date with new knowledges. If the prototype had limited scope in the applicable knowledge domain, then extension of the system will be required until the entire knowledge domain can be provided by the system.

Stages 5, 6, and 7 are stages that will occur assuming a successful prototype is developed. They are routinely not addressed to any degree until the prototype has been developed. They are presented here only to reflect the experience of real systems that have been developed such as R1. They can be anticipated, but not well planned for early in the assessment process.

4 EXPERT SYSTEM DEMONSTRATION MODULE

A hands-on test of applying expert systems technology to a civilian personnel function was undertaken during the course of this project. This examination served two purposes. It allowed me to try actually developing an expert system, as limited as it was, and it produced a functioning demonstration module to allow others to see how expert systems technology might be implemented in the civilian personnel administration area.

A software package called Expert Ease was used for development of the demo module. This program is intended to be an expert system development tool for non-programmers to use in developing expert systems. It had its limitations, but served the purpose of allowing me to prepare a small demo module. The functional area chosen for the demo module was job classification, primarily because it appeared to offer the most straight forward application, and also because I have a background in position classification. Additionally, there were other personnel available in the San Francisco Field Office to examine the operation of the module and offer suggestions on how to improve its performance in arriving at correct classifications of jobs.

In order to keep the expert system on familiar ground, I approached the design of the expert system to mimic, as closely as possible, the OPM classification system. This gave me some insight into the problems that would be faced by an expert system developer if a full scale project were undertaken to mimic our current system, and it would result in a demo module that would be recognizable by others who would see it.

I first attempted to develop a module to classify a secretarial job. This attempt was abandoned after working with it for a couple of days. It proved to be extremely complex to try to cause the system to mimic OPM classification guidance, and Expert Ease did not appear to have the capability to encompass the problem without a very convoluted mass of files. This would cause the demo module to run very slowly just to classify one secretarial job since it would have to call in a number of files to fully examine all the factors involved in the classification process. As discussed elsewhere in this report, it may not be a wise choice to try to develop expert systems for the civilian personnel administration functions that exactly mimic current systems. Although I believe they can be so developed, perhaps the investment in time it would take to cause this to occur would not be a cost effective utilization of expert systems technology. This needs to be more fully explored with better software tools

than I had available.

I turned to the wage grade area to work up the demo module. It was a relatively easy task to prepare the module. In order to have some variety in it, I chose three broad occupational groups; equipment maintenance and repair, operation of equipment, and food service and preparation. Within these three broad categories, I chose the specific occupations of; Automotive Mechanic, Mobile Equipment Servicer, Air Conditioning Equipment Mechanic, Fork Lift Operator, Crane Operator, Motor Vehicle Operator, Cook, and Food Service Worker.

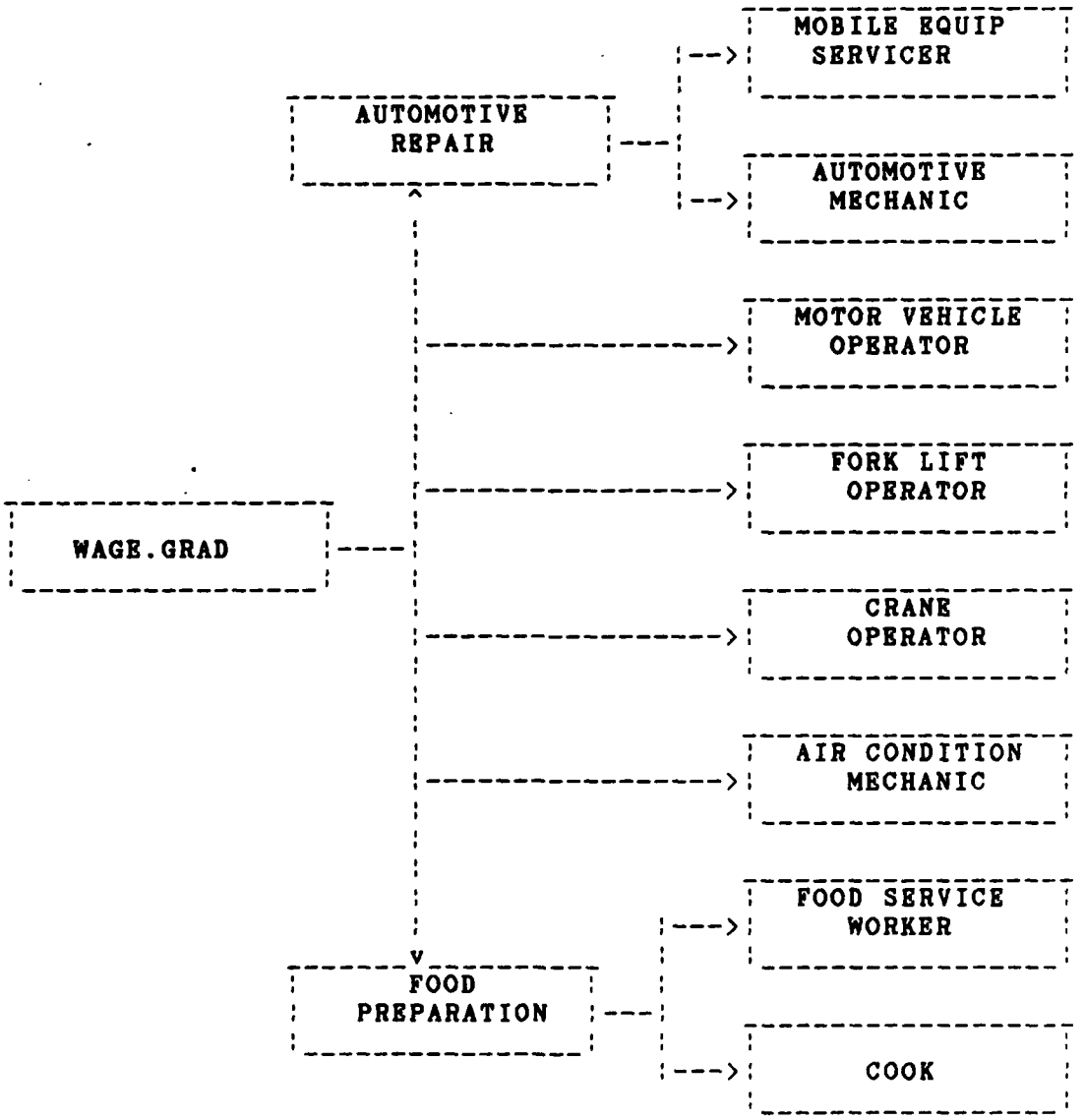


Figure 1: Flow chart for Wage Grade demo module of expert system.

The demo module is composed of eleven files. The main file, called WAGE.GRAD branches to six other files, two of which branch to two other files each. The flow chart for this file structure is depicted in Figure 1.

A forward chaining technique is utilized in the module. This technique uses decisions reached in one file to cause forward chaining to the appropriate file for further decisions. In practice, this technique could have been used to classify the secretary job.

The user interface of the demo module employs menu selection choices and some numerical input responses requested of the user by the system. This interface choice was driven by the Expert Ease software. More powerful systems development tools, such as HEARSAY-II and III, and AGE provide some natural language interface capability, thus a more free flowing interaction between the system and the user can be designed.

The demo module begins by querying the user for the main category in which the job falls. It then asks pertinent questions, if necessary, to further clarify for itself which classification file it will use to classify the job. The demo module eventually locates the appropriate file to be used to classify the job. A series of questions are then presented to the user to elicit information that will be used in the actual job classification process by the expert system demo module.

Different modeling schemes were used in the development of these files to be used in the classification process. For example, a rather simple model was used for Air Conditioning Mechanic which is dependent on asking the user about the degree of supervision provided to the employee of the job being classified, up to ten questions about knowledges required of the worker, and a question about whether air conditioning equipment being repaired is directly involved in experiments or tests of other things. This model will result in a grade of WG-11 if little or no technical supervision is exercised over the employee, work does involve a "testing" environment, and nine or ten of the knowledges are specified as being required. If only eight of the knowledge questions are answered affirmatively, and the other elements are the same, a grade of WG-10 results. If work is not done on "test" A/C equipment, and eight or more knowledge questions are answered in the affirmative, a WG-10 results. If any number of knowledge questions less than eight are answered affirmatively, or if supervision is closer than a certain level, then a grade of WG-8 is assigned. This model was chosen to partially guard against those who would try and cheat the system. It assumes any journeyman A/C mechanic would need to possess most, if not all of the knowledges represented by the knowledge questions. It prevents a WG-11 classification unless the A/C mechanic is actually working on equipment directly used in experiments and tests. The model is designed to be on the conservative side in allocating the job.

The model as described above is not known to the user, nor are any of the models in the demo module. Expert Ease does not provide a facility so that the user can ask the system why a particular question is being asked. Most expert systems in use today do provide a means for the user to ask the system why it is seeking any particular piece of information. The system will respond and advise the user of the rule it is trying to use, or give other indication back to the user what the information being sought will be used for.

While the A/C Mechanic model is relatively simple in concept, Expert Ease had a dickens of a time dealing with it in inducing the rules to be used in making a decision. After setting up the attributes and values, I had to develop 188 examples (combinations of responses to attributes) for the system to use in the induction process. A rule (decision tree) of 373 nodes resulted, and it took the system 15 minutes to make the induction. Normally, a 30 node rule is about all Expert Ease is equipped to handle. From the program's point of view, this is a very complex model.

Other models used were somewhat more complex from a personnel viewpoint, but relatively simple from the program's point of view. For example, the fork lift operator was initially modeled on the concept that if the operator were required to operate a fork lift of 10,000 pounds or more, a grade of WG-06 resulted, and if the fork lift had a capacity of less than 10,000 pounds, a WG-5 classification was made. After discussing this model with Mr. Bill Dittmar in the Field Office (an expert classifier), the model was changed to get at the subtle differences in outside work with a fork lift vs. inside work. This expert consultant input was used to modify the model so that the system will produce a WG-5 even if the fork lift is over 10,000 pounds, providing certain criteria are not present, and could even result in a WG-6 for an operator with a small fork lift under certain conditions. Although further refinement could be made to the model to more accurately carve out the criteria necessary for a classification that is not necessarily inextricably tied to the capacity of the fork lift, the refinements made do point out the flexibility of designing expert systems that follow the logical thought processes of experts, and give expert answers.

Some conclusions can be drawn as a result of using Expert Ease to develop the demonstration module:

1. A much more powerful expert system tool will be required to attempt to create any usable expert systems for the personnel administration functions. This was not a surprising conclusion. Our business is entirely too complex for any but the most powerful applications software. Using a language, such as LISP or PROLOG is a viable option in expert systems development for personnel administration. Some of the tools on the market such as EMYCIN, ROSIE, HEARSAY-III, and others may posses the power to handle the problem. The choice of using a tool, a language, or both will need to be decided by the actual developer of the

system, should a system be approved for development.

2. A major decision will need to be made whether or not an expert system for personnel administration should exactly mimic current systems, or if new policies and changes in systems will be implemented as the system is developed. This is a very critical issue and requires a policy decision. It became obvious to me as the module was being developed, that the expert used in shaping the decision processes the system will imitate, is the crux of the entire system. For example, one could find little reason to make any further distinctions in classifying a fork lift operator job than the capacity of the fork lift. One could further refine the system to get at more subtle differences in work performed, as I did with the demo. The final demo could be even further refined to account for a multitude of minute nuances pertinent to a fork lift operator job ad infinitum. The choice of just how detailed one wants to make the system, and whether or not new policies are instituted as a system is developed is an important one. Due to a need to have some basis of comparison between our current system and one operated under an expert system, I believe such a system should mimic our current system. This would also make it easier to find "experts" for the development process. However, any such system would mimic THAT expert or, THOSE experts used in the development.

3. This brings me to experts. It would be clearly a disaster to attempt to build an expert system using the committee approach to "expertise". A knowledge engineer attempting to deal with a group of "experts" in developing a system would never complete the task. This is not to say that additional experts should not be used to test the system, and make adjustments. This is a normal practice in expert systems development. This is also not to say, that different experts should not be used in different areas of expertise, they most certainly should be. However, during the initial development stages, the knowledge engineer would need to have available the representative that would serve as the model whose knowledge and expertise will be used for modeling the system's expertise.

4. It is possible to build in many checks and balances to the system. For example, in the area of classification, a fear might be that the supervisor could manipulate a particular grade out of the system if he or she were knowledgeable of the standards or the modeling that went into the building of the system. This is not too unlike our current system, however, we enjoy the added benefit of a classifier on site to demand proof of claims about jobs. It must first be decided whether or not this kind of checking is important. And this is a very significant decision. If it were decided that some method of verification needed to be provided for in the system to guard against unscrupulous supervisors, then there are ways to do this. For example, in the area of classification, the employee could be required to interact with the system on a periodic basis to reaffirm that critical grade controlling duties had in fact been performed. Another way to deal with the issue would be to tie

the time-card system into the personnel system, and provide for time keeping on a task basis. If tasks did not match the grade level of the employee, a flag would be raised. And, of course, follow up reviews by classifiers could be conducted. It is obvious that this is a very critical issue, and needs to be decided early on, if an expert system is pursued.

5. Finally, even in using this very limited tool, I was encouraged that expert systems technology can indeed be applied to the personnel administration business. It is as if major parts of our business were made for this technology. Much of what we do is rule intensive, and so are expert systems. Most of what we deal with is non-numeric data, and expert systems handle this kind of information well. Experts in our business do exist, and they can vocalize their expertise, which expert system builders need.

The demonstration module, while very limited in scope, allowed for a trial application of expert system development. It can be used to demonstrate the technology, and has provided insight to this researcher into some of the techniques used, and problems that can be encountered.

The complete set of models are contained in Appendix E. They are printed in Expert Ease format. Each model contains the attributes file with the questions that will be asked by the system, the examples file which shows the examples used to induce the rules, and a rule file which is the decision tree used by the system to provide an answer.

It is not possible to provide the floppy disk containing the demo module with any except the original copy of this report. A copy of Expert Ease is required to run the module. Expert Ease is copyrighted and can not copied and further distributed (besides it's copy protected, too).

An examination of the ability of this demonstration module to accurately classify jobs in a real-world setting was undertaken. Results of this test are summarized in Table 1. The method used was to have a supervisor use the system to classify an actual job over which the supervisor was responsible and knowledgeable. These tests were conducted at the US Army Yuma Proving Ground, AZ. The test plan was initially designed to compare classification results of the demonstration module against a human classifier in terms of accuracy and time expended making the classification judgment. The plan was modified after it was discovered that many of the jobs contained mixed duties, i.e. not purely of one occupational category.

It was also discovered that some of the questions contained in the module needed to be adjusted in order to more accurately apply expert judgment, and remove from the questioning process any opportunity for the user of the system to apply judgment. For example, the module that classifies crane operator jobs contains a question about precision operation of a crane. The

question is: "Will the boom crane be operated in any of the following situations? Load and unload equipment and supplies on board ships. Precision set objects such as guns into mounts, sonar equipment on to ships, or wings on to aircraft. Dig and move earth or rock close to buildings, walls, or underground obstructions. Destroy brick and stone structures near high-voltage power lines or other structures." The supervisor who used this module answered yes to this question, but when asked the percent of time spent so operating the crane indicated only 5%. The end result was a Crane Operator W-09. The job is classified correctly by the classifier as a W-11. The reason for the difference lies in these two questions.

When the supervisor answered the question, he did not consider the placing of gun shelters at firing positions as precision use of the crane as defined in the question. Thus a large part of the employee's work time was not included in the following question about percentage. The classifier who had classified the job had made the judgment that placing of gun positions to be precision use of the crane, which when added to other precision use of the crane resulted in at least 25% precision operation. This pointed up a problem with the module which did not solicit enough information about crane operation to make a judgment about precision use. Therefore more development of the module would have to be undertaken to rectify this problem. A similar problem was found in the AC mechanic job. In this case, the supervisor was asked to make a judgment about mechanics who serviced equipment that had a direct effect on tests. The module needs to be modified so that supervisors respond to questions non-judgmentally, and provide for the judgment to be made by the system.

Table 1 shows the results of the tests conducted at Yuma Proving Ground. I believe the tests are inconclusive at proving or disproving the ability of the demonstration module to classify the jobs even though the module did accurately classify 6 of 8 jobs.

JOB	COMPUTER	CLASSIFIER
Crane Operator	9	11
AC Mechanic	11	10
Motor Vehicle Operator	7	7
Motor Vehicle Operator	8	8
Mobile Equip Servicer	5	5
Automotive Worker	8	8
Automotive Mechanic	10	10
Fork Lift Operator	6	6

Table 1: Test Results of Demonstration Module vs. Human Classifier.

The value of these tests lie in the kind of information gathered from the supervisors as they used the module, rather than the accuracy with which the module classified the jobs. When the system provided a classification, the supervisors felt that the system did not ask for enough information, even if the classification seemed to be correct. The average time expended by each supervisor on each job was about 3 minutes. Much of this time was wasted by the system loading files. When the answer was provided, the supervisor's reaction was invariably "is that all?" This reaction is attributed to the past experience of our supervisors who are accustomed to being asked many questions, and showing classifiers what the job is all about. As has been my experience, classifiers, for good reason, gather many more facts about a job in preparation of classifying it than is actually used in the classification process. Many times, classifiers gather these non-essential facts in order to give supervisors and employees the feeling that the job has been thoroughly reviewed.

It may be necessary to build an expert job classification system that queries the supervisor for many, many facts, even though some of the facts are non-critical to the job classification process. This may be particularly true in the transitional phase over several years until our supervisors become accustomed to the automated approach to job classification. This is an area that requires further assessment as a prototype expert system is built.

5 WHERE EXPERT SYSTEMS COULD BE USED IN CPO

There are numerous areas in which expert systems technologies could be put to productive use in the civilian personnel administration functions. Practically any function in which personnelists apply knowledge to the solution of problems is a candidate for expert systems. As discussed in the previous chapter, an expert system could be developed to classify jobs. Systems could also be built to make qualifications determinations, to advise on health benefit plans for employees, to advise on disciplinary actions (penalty to assess, whether a case is sufficient, etc.), to make determinations for non-government training approvals, to help assess negotiability issues, to make pay setting determinations, and to conduct RIF's. In fact, I believe there are few areas in our business in which expert systems could not be put to use.

Some functions performed by personnelists could not be efficiently handled by expert systems. These are invariably those things personnelists do that are intended to influence others behavior. For example, labor negotiations could not be handled directly by an expert system. Humans are definitely required at the bargaining table. However, expert systems could be put to use to advise the human negotiators to do their job better. Employee counseling by personnelists in which behavior modification is a goal could also not be accomplished by a computer. Those activities in which personal interaction is a necessary part of the process in order to make assessment of non-verbal signals such as body language, facial expressions, tone of voice, etc. are not candidates for expert systems.

Those functions that are principally application of rules, whether the rules are written regulations, or general principles learned through experience, are prime candidates for this technology. For example, the determination as to whether or not an employee has retreat rights to another position during a RIF is based on the application of several rules. One must determine if the position in question is one from or through which the employee was promoted or which is a position that is substantially the same as a position from or through which the employee was promoted. These determinations are sometimes simple facts (i.e. the employee WAS promoted from the position), and sometimes judgments (i.e. substantially the same). The judgment whether or not the position is substantially the same is based on an expert assessment of the position in question. The same knowledges used by the expert to make this judgment can be captured by an expert system which could make the same judgment.

Not only could this judgment be made by the expert system, if the system were built to conduct RIFs, and the assessment of retreat rights were part of the design, retreat rights would never be simply overlooked by the expert system as they might be by humans who conducted the RIF.

As discussed previously, expert systems make use of a technique known as production rules that take the form of IF - THEN. In many ways these rules are similar to the rules contained in regulations that guide the operations of personnelists working in this field. Frequently, regulatory rules require interpretation by personnelists in order to be applied correctly to a given situation. As in the forgoing example, one could not expect any supervisor or employee to adequately apply the "substantially the same" judgment to a given situation. In order to make this determination, a personnelist with considerable experience must apply his or her expertise to the problem, and make the call. What the personnelist does in making the call is based on gathering additional facts (review the job in question) and apply rules that have been formed through experience. These rules are the knowledge that must also be built into an expert system in order for it to function at the human expert level.

Since rule based techniques are used to implement an expert system, then an approximation of the number of rules that would be required will help to estimate other things, such as time to develop, size of the system hardware, and complexity of the software tool needed. Therefore, I attempted to make an estimation. This area of rules estimation is not well understood even by the experts. It seems that one cannot, in advance, predict with any degree of certainty just how many rules will be required to capture the expertise in any given knowledge domain. The field is so new, and experienced knowledge engineers so scarce, little has been done to develop a reliable method of estimating rules.

Review of existing expert systems, and the number of rules involved in their operation does not shed much light on the problem. R1, Digital Equipment Corporation's computer configurer has varied over the years in the number of rules it has. For example, the initial system had 777 rules, and recently it was reported to have grown to 3303. Most of this growth was due to extending its capability to configure additional computers. Over the years, it has had ups and downs, as new rules are created, and others dropped, or refined. However, it is not possible to evaluate the number of potential rules in one knowledge domain based on any other knowledge domain.

If one were to count only the rules that are well formed in the personnel business, then it would be a fairly simple matter to examine the regulation involved and count the rules it contained. For example, the rule that an employee must have a college degree in library science as a prerequisite to qualifying for a librarian job is relatively well formed. However, the rules that must be created to evaluate even general experience for a

clerical position are not well formed. Staffing specialists are very adept at reviewing work experiences of employees and determining whether or not the general experience requirements are met, and they, in fact, are applying rules when they do this. These rules of thumb based on years of experience, are the essence of the knowledge engineering process to build the expert system. Attempting to estimate just how many of them there are for any specific process is simply not a very precise endeavor.

My methodology for making an estimate was based on a rudimentary understanding of what rules look like in expert systems, and how they are used, my experience in the knowledge domain of personnel administration, and the little hands on development of the demonstration module which classifies eight wage grade jobs. I selected five white collar occupations, examined the standards pertaining to them, and conducted an analysis of the number of apparent rules that applied to making decisions about various factors contained in the standards. Searching through the standards in this manner, I counted the number of what appeared to be rules that would have to be written into an expert system in order to make decisions about the various elements and issues involved in solving a problem of deciding the grade of a job. Figure 2 contains the estimated number of rules required to classify a job in the Budget Analysis Series, broken down to rules for each factor.

Factor	Rules
Series Determination	25
Knowledge Required	105
Supervisory Controls	80
Guidelines	50
Complexity	75
Scope and Effect	60
Personal Contacts	15
Purpose of Contacts	20
Physical Demands	1
Work Environment	1
Estimated Total	432

Figure 2: Estimated number of rules for classifying Budget Analysis Jobs.

I did not attempt to write any of the rules that appeared to be required for this decision process. An example of a rule under Personal Contacts might look like this (in English): "IF there are recurring face-to-face and/or telephone contacts with members of Congress and/or top Presidential advisors THEN consider a value of 110 points with a certainty factor of .90". Production rules such as this are formed in English, then reduced to code in the language being used to build the system.

Figure 3 gives the estimate of the number of rules that might be required in the five occupational categories I examined. The differences between the two engineering occupations is attributable to the two different kinds of standards involved.

Occupation	Rules
Budget Analyst	432
Mechanical Engineer	190
Electrical/Electronic Engineer	400
Secretary	367
Supv Grade Eval Guide (I & II)	315

Figure 3: Estimated number of rules required to classify jobs in selected occupational categories.

The Mechanical Engineer standard is in FES format, while the Electrical is not. Reflecting on this, I seemed to generate a lot more rules in my head when trying to make distinctions using the narrative format standard. It is also interesting to note that the FES Budget Analyst jobs resulted in a number of rules similar to the non-FES Electrical Engineer. I can only say that the job of trying to estimate rules is extremely hazardous and speculate that it might take about 400 rules for each occupation to be classified.

The estimates are for job classification purposes only. My attempt to assess the number of rules for qualifications determinations for the same occupations did not allow me to use the same process as I used for job classification purposes since I have very little personal experience as a staffing specialist. Using somewhat the same techniques, however, I estimated approximately 200 rules for the Budget Analysis Series. This did not approximate the classification rules estimate, so since I did not feel I had the requisite background in staffing, I made no further attempts to get a handle on it using an evaluation methodology. It might be safe to assume that the two are somewhat equal based on some equality in the amount of time it takes to make judgments in each area by practitioners of the disciplines.

This process of rules estimation helped me to form the recommendation in this report that the next step in examining the application of expert systems to the personnel business involves the development of a prototype. Accurate assessment of the number of rules required for any specific functional area can only be made as a result of the developmental process.

Expert systems can definitely be used in CPO functions. How these expert systems will be used (i.e., by whom) is explored in the next chapter.

6 STRATEGIES FOR USE

Most of the expert systems that were developed during the gestation period of this technology in the research settings of universities were designed to be used by specialists in the knowledge domain. MYCIN was designed to be used by doctors who were not expert at diagnosing infectious diseases. MYCIN's main usage is in a hospital setting in which the patient appears to have contracted an infectious disease while in the hospital for some other reason (e.g. surgery). The patient's doctor can use MYCIN with fragmentary test results such as lack of cultures which require several days to grow in order to make positive diagnosis. MYCIN serves as an expert who is extremely capable of diagnosing meningitis, for example, without the full complement to cultures, etc. that take time to get. The terminology used by MYCIN would not be understandable to non-medical personnel, and could not be used by them. One must be a medical doctor to use the program. PROSPECTOR likewise must be used by geologists since the terminology used would not be understood by the man in the street.

The design of an expert system for a knowledge domain in the field of personnel administration must first be assessed in terms of who would use it. It is one thing to build a system to be used by personnel people capable of making some judgments and understanding specialized terminology, and it is another to build a system that is capable of advising or taking action based on input by nearly anyone. For example, the term 'planned management action' is a fairly well understood phrase by journeyman level personnelists. The phrase is much less understood by supervisors and employees. Therefore, a system that has been designed to advise personnelists in a particular functional area could refer to the phrase with a question such as "Is this the result of a planned management action?" in order to gather information for an advisory function in say a merit promotion action. However, if the system were being designed to be used by supervisors or employees directly, then information would have to be gathered in another manner in order for the system to make the initial judgment as to whether or not a planned management action had been taken before moving on to the area in which this information would be used.

It is possible to design an expert system in the personnel business to serve as either an advisor to supervisors and employees, or as an advisor to personnelists. Obviously, a system designed for personnelists use would be much smaller due to the lack of need to have it make interim judgments about common terms and rules well understood by the personnelist users.

There are some areas in which such systems would be the natural choice. For example, an expert system designed to advise a personnelist on negotiability issues to be used at the bargaining table could be built without ever expecting the system to be used by employees who are not knowledgeable practitioners in labor relations matters.

Other areas of personnel administration do not offer such obvious choices. Job classification, for example, is one area in which the system could serve as either a classier's expert advisor in grading difficult jobs, or it could serve as the classifier proper, and grade jobs based on supervisor or employee input. Since supervisors and employees are knowledgeable of the job, its tasks and responsibilities, it appears to be feasible to design an expert system to serve as the classifier (expert) that draws facts and information about a job from a supervisor, and makes the classification judgments based on this information. It is very important, and a considerable challenge to use carefully chosen terminology that does not demand of the user a knowledge of the classification process, nor the ability to understand specialized terminology, nor the requirement to make judgments about meaning of terms. I attempted to do this with varying degrees of success with the demonstration module. For example, rather than asking whether the crane operator was required to make precision placement of loads with a crane, which would require the user to make a judgment about what is, or is not 'precision', I attempted to ask questions about specific operations which were known by the module to be precision tasks, without requiring the user to make a judgment. The design of these questions, ridding them of any requirement for the user to make judgments about the meaning of terms, is probably the biggest challenge to developing an expert system to be used directly by supervisors and employees.

While this challenge is great, I do not believe it to be insurmountable. Nearly any specialized term used in personnel jargon can be "de-personnelized" with other terms, examples or explanations.

I believe a goal for system development needs to be set to design a system for direct supervisor use. This belief is based on practical considerations. While there are some areas in which expert systems could be put to use in a personnel office that would serve as experts to knowledge workers (personnelists), the biggest payoff of an expert system would allow for its use directly by supervisors and employees. In this manner, actual savings could be realized by replacing personnelists with the expert system.

There are other issues that relate to the use of expert systems in this manner that are perhaps more difficult to accept from a policy viewpoint than from a technical consideration. These involve the manner in which personnel administration and management operate within the agency. While it is a stated policy that the supervisor IS the personnel manager in Army, much

of the time expended in a personnel office by personnelists is aimed at not only advising the supervisor of things that should or should not be done, but also of forcing or preventing things. The police roll of personnelists is steeped in tradition, and reinforced through various influences such as training courses, inspections and surveys, and reporting procedures. Some of our functions are more heavily engaged in police work than others. For example, Position Management and Classification is at one end of the scale, while Training and Development is probably at the other. With an expert system that is directly operated by supervisors and employees, the opportunity for supervisors to circumvent the police roll personnelists play is increased.

I attempted to get this issue addressed by some of our most highly placed personnelists in Army through a questionnaire that was handed out at the Professional Development Seminar on 2 May 1985, in the Pentagon. Approximately 50 key professionals attended the seminar and were asked to respond to a questionnaire which had the issue of direct supervisory use of expert systems identified (the questionnaire is at Appendix I). Of those attending only three responded to this questionnaire. During the seminar, three groups were formed to discuss the concepts and issues of experts systems, and a report of their deliberations which covered most of the issues identified in the questionnaire was provided to DA. Those reports are enclosed at appendix I. I also handed out the questionnaire after giving a briefing on expert systems to attendees of the Western Area CPO conference held on 13 May 1985 in the San Francisco Field Office. Of approximately 20 attendees, only three responded. These responses are summarized at Appendix I.

I have interpreted the responses, and non-responses, from these attempts to get the issues addressed as a "wait and see" attitude. Other interpretations could be made such as "indifference", or "don't understand", but I believe the correct one is generally cautious observation from the sidelines. This is not unusual. It has been observed by others that most new ideas are not immediately embraced, nor totally rejected upon first introduction.

In any event, the issue of who the intended user of an expert system will be needs to be decided early on. One cannot begin development until one knows who will use the system. The user interface is a key ingredient in any expert system, and is developed along with the the knowledge base and inference engine.

Recommend the targeted user of the expert system prototype to be proposed in a later chapter be supervisors and employees. This will give the greatest potential for savings.

7 HYPOTHESES FOR EXPERT SYSTEMS USE IN CPO

One of the major tasks undertaken in this project was an assessment of whether expert systems could be used in civilian personnel administration functions, and whether they should be. Five major hypotheses were formed as a result of my assessment, and will be presented in this chapter of the report.

Hypothesis 1. Expert systems technology can be applied to civilian personnel administration functions. My conclusion on this hypothesis is affirmative, and is based on the following findings.

First of all, much of the civilian personnel administration business is a knowledge intensive activity. That is to say, the majority of things that are done by personnelists is based on a highly specialized area of knowledge. Classifiers deal daily with knowledge about jobs, e.g. what are typical and non-typical tasks found in various jobs. They apply knowledges about how jobs are classified, what constitutes a major duty, how organizations are efficiently structured and so forth. Staffing specialists deal with knowledges about amount and kinds of experience and training that qualify people for jobs, what the potential for filling various jobs is, how to set pay and so forth. Most of our daily work is knowledge intensive as opposed to skills intensive such as operating a piece of equipment.

Expert systems technology directly applies to, and works extremely well with knowledge intensive domains. Expert systems are frequently called knowledge based systems. Thus it can be expected that our knowledge intensive activities are ideal candidates for expert systems applications.

Second, personnel administration is a rules oriented function. Our knowledge is based heavily on applying rules to specific problem situations. Many of our rules are highly structured and in fact written in the form of regulations, manuals, policies and the like. This is not to say that ability to interpret rules, and convince others of their acceptance is not important. Interpretation is another form of knowledge application, while the ability to convince others of their acceptance is a skill. However, the accurate application of rules to problem situations is a very major part of any personnelist's daily activities.

Expert systems are very well suited for knowledge domains in which rules are well formed and play an important part in the function. Many expert systems are dependent on rules for their

proper functioning. Using IF - THEN production rule constructs, expert systems technology fits well with our heavily rules oriented activities.

I have therefore concluded that much of our personnel business seems highly compatible with this technology, and that expert systems could accomplish many tasks performed by knowledge workers in this domain.

Hypothesis 2. If expert systems technology is applied to our knowledge domain where applicable, then we can save money for the American taxpayer.

It is possible to develop an expert system that can be used by persons without specialized knowledges of the domain. Financial institutions are developing systems to be used by non-specialist personnel to make analysis for granting loans, marketing departments are developing systems to advise and train salespersons in new products and configuration technicalities, and other similar developments are under way. An expert system could be developed to be used directly by supervisors to provide advice and take actions that personnel people now do. In this manner, the number of specialized knowledge workers could be reduced since the expert system is performing many of the their tasks. A gross approximation of possible savings appears in another chapter of this report.

I have concluded that cost savings could result with the application of expert systems by reducing the number of knowledge workers in the civilian personnel functions.

Hypothesis 3. If an expert system is put into place, responsibility and accountability for personnel management can be fixed directly with whom current Army policy states it belongs - the supervisor.

With an expert system that is being directly operated by supervisors to accomplish personnel actions, the supervisory input to the system is the immediate and responsible cause of the system's resultant activities. Given the assumption that the system is performing as a human expert would perform with the same facts, any inappropriate, irregular or illegal results produced by the system would be attributable to false facts. Since critical facts are provided by the supervisor user, the supervisor assumes the full responsibility and accountability for the outcome.

My conclusion is that an expert system insures accountability and responsibility in the knowledge domain in which it is functioning.

Hypothesis 4. Improved consistency of personnel administration on an Army-wide basis will result from the application of expert systems technology.

This is fairly obvious. After a system is developed, certified expert, and placed in operation as a standardized system, identical results would be obtained given identical facts in all locations throughout Army. Although we do not like to admit it, human specialists do not always provide the same degree of consistency. One could argue that consistency is not supreme, and even argue that what might be lost with machine performance (personal contact and human involvement) is not preferable to some inconsistency. I will not attempt to debate that issue in this report.

My conclusion is that consistency of results is maximized with the use of expert systems performing functions now performed by personnelists.

Hypothesis 5. Timeliness of service provided in personnel administration matters will be orders of magnitude better than present performance.

First, computers are simply faster than humans at some tasks, particularly difficult ones. In some cases, humans do outperform machines, particularly in areas of cognition. There will be some tasks in which the expert system will not be a match for a human expert. Most actions that are taken by personnelists throughout Army are not being taken by experts, but rather specialists. If all of our specialists were experts, perhaps humans would outperform machines. On the whole, however, computers will be able to accomplish tasks faster than is currently possible with our personnel specialists.

Secondly, and probably most importantly, there is no wait time with an expert system. Much of the total processing time of any action under our current system is actually wait time in which no one is doing anything with it. It is laying in an in-box. Not because there is a human sitting there doing nothing while the action sits, but because the human is doing something else. With an expert system, wait times are measured in micro-seconds, not days. With the system available at the work site of the supervisor, action would be taken immediately by the computer to respond to the supervisor and begin the processes of solving the problem or taking the action. State-of-the-art multiuser computer systems share CPU time so efficiently that the user is unaware that the system is responding to more than one user. Humans simply can't do this.

My conclusion is timeliness would definitely be greatly improved in any area in which expert systems are appropriately applied.

These conclusions not only indicate that expert systems can be applied in our business, but that perhaps they should. At least there is enough positive evidence that they should, that I believe the next step needs to be taken. Some of the issues cannot be realistically assessed without a system in operation. For example, it is prue conjecture whether or not supervisors will try to cheat the system, given the chance. The next step is

the prototype development stage. The scope of the system needs to be defined, a prototype developed, refined, tested and placed into operational test mode in parallel with the current way of doing business and assessed. This will be discussed in the next chapter.

8 A PROTOTYPE SYSTEM

Expert systems technology can definitely be employed in Army's civilian personnel administration functions. It is therefore recommended that the next stage of development be undertaken. During this stage, a prototype system will be developed. This section will delineate what the expert system would do, and not do as a result of this developmental stage. It is an outline that could serve as a guide for the project development team. It must be recognized that a project office would refine the scope, functions and details of the expert system as it is developed, thus the following outline would expectedly be deviated from as the system is developed, and more experience is gained with what is and is not possible.

It is proposed that the demonstration project be limited to the PM&C function of personnel. As discussed elsewhere in this report, the number of rules associated with the entire personnel administration function is astronomical. Trying to develop an expert system from scratch that would encompass all functional areas of personnel, at one time, is simply too large of an undertaking to consider. It would literally take years to develop, and with regulations constantly changing, it may never be completed, and placing it into operation for test purposes could not be accomplished. I would therefore recommend a modular approach to development, utilizing the PM&C function as the area to test first. When this results in a successful expert system, then other functions could be added incrementally. In this manner, the entire array of civilian personnel administration functions could eventually be integrated into one cohesive system.

This recommendation did not come easily. During my research, I continued to hold on to the idea to, at a minimum, bring the three major functions of classification, staffing and performance management under a test program, and limit the size of the organization being serviced so that it would be small enough for the system to handle. The reason for trying to maintain this concept is due to my belief that these three functions are inextricably intertwined, and should be considered as a whole by supervisors and employees as well as personnelists. I believe we have an artificially segmented system when we cause supervisors to visit one set of specialists to get a job established (classified), another to define the criteria by which candidates will be evaluated for potential placement in the job, and yet another set of specialists to identify the performance criteria by which the employee will be measured. In each functional specialty, many of the same factors are discussed, examined,

defined and described, with a slightly different angle being explored for the factor. It seems efficient to me that the discussing, examining, defining and describing of these factors should be done all at the same time with the slight change in angle being satisfied for each specialty.

I feel strongly enough about this opinion that I held on to the integrated concept for as long as I could. However, I eventually had to drop the idea in favor of actually developing a prototype system. I made the assumption that any expert system would have to closely mimic our current system in practice. The sheer size and complexity of each functional specialty varies. For example, the staffing function has literally scores of regulatory and policy issuances that come to bear, some on nearly every action, and some very rarely. All of the rare rules applications would have to be built into a system in order for it to replace the knowledge workers involved in staffing functions and mimic our current system. While this is definitely possible, the time it would take to develop an expert system that covered the entire staffing function AND the classification function would more than double the time it would take to produce a system covering only the PM&C function. The performance management function, with little real expertise currently in existence (in comparison with Staffing and Classification) would probably be the easiest and quickest expert system to develop.

I have also assumed that Army would expect a system to be placed into operation for test purposes within about three years of its approved go ahead. To spend any more time in the development phase of a project without bringing it to beta testing and then on line use would be unreasonable.

Some of the things I considered which caused me to recommend PM&C rather than R&P or some other function are as follows.

Position classification expertise is a relatively logical and structured knowledge domain. I believe rules could be generated with expert system development tools that would result in accurate classifications, and would be acceptable to the experts knowledgeable in this domain. The user interface, i.e. the part of the program that queries supervisors and employees for input, appears to be a problem that can be solved, and would not involve an inordinately different problem from the knowledge engineering process itself. What this means is, as the knowledge engineering is accomplished to "teach" the system its expertise, the user interface closely parallels and resembles the rules that would be written. By comparison, this is not necessarily as close a parallel in such things as candidate evaluation, therefore a separate, but related programming effort would be required to generate a user interface for such functions.

Another consideration is the resultant system in an operational mode. While it is most desirable to have the system available on site at every work place, this simply may not be possible for the test phase of the prototype. Very few fully distributed ADP

networks exist in the Army today, in fact none that I could find. Although most installations have considerable automation efforts under way, I would not expect full networks available to all supervisors at many activities by the time this system is ready for operational purposes. Given these circumstances, the PM&C module is more amenable, than other personnel functions, to being made available at a few sites at an installation, or only in the personnel office. Supervisors could then visit the location of the system and obtain PM&C services. This should not cause a traffic jam since the frequency with which supervisors initiate new PM&C actions that require full classification services is not that great (at least in comparison with the R&P services).

Given the above assumptions and considerations, I recommend the prototype system be developed for the Position Management and Classification function in personnel.

The development of the PM&C expert system should insure that it accomplishes all of the tasks now performed by classifiers and others assigned to a typical civilian personnel office PM&C function. While it may seem superfluous to specify these tasks for the benefit of personnelists, I am including a summary of these tasks for those who might read this report that are not personnelists, and to provide the outline for the development of the system.

The test system would be equipped to classify all positions in the organizations serviced. The method used would be direct supervisory input to the system, with the system prompting for the required information to make an accurate classification of any job in the organizations. The system must be "smart" enough to recognize when it is dealing with a job for which it cannot provide a classification, and report same to the user, as well as notify people in the personnel office. Thus, for example, if the system is designed to service a Comptroller, a Procurement Office, and a Personnel Office, and a serviced supervisor developed a need for an engineering technician that was not projected by the system developers as a probable occupation in any of these functions, the system would recognize that it could not classify such a job, and make appropriate notifications. This job would then have to be "person classified" outside the scope of the system.

Mixed jobs must be acceptable to the system, as long as the tasks relate to jobs for which the system has been developed. The system should be equipped to make FLSA determinations on all jobs it can classify. It should also assign competitive level codes, and make functional classifications if engineering positions are included. It would also have to produce correct supervisory and non-supervisory indicator codes.

The system would prepare a job description based on the interactive process with the supervisor. The job sheet would be printed, and an evaluation rationale also produced. The evaluation rationale would essentially be a listing of the rule

firings that were used internally to make the classification judgment. It would also be a record of supervisory responses to questions posed by the system, thus providing an audit trail of the supervisory input. This may help to keep supervisors honest.

The system would also perform maintenance reviews. This function would be performed by the system prompting for information from both the supervisor, and the employee on the job. Inconsistencies of information provided by each source would require that they be resolved before the system would verify accuracy of the job. For example, if the supervisor specifies that a particular duty is still required in a job, and the employee replies that he/she has not performed the duty in the last year, this inconsistency would have to rectified, and the system would require its resolution.

Hazard pay and environmental differential determinations would be made by the system. This would be an on-line service in which supervisors or employees who feel work being performed warrants HDP/EDP, could query the system for advice and determinations as to whether the premium pay is warranted. The system should be capable of making a determination, issuing a certification of work judged to meet criteria for payment, and notify all appropriate offices and persons.

Position management advice and recommendations should also be a service provided by this system. This will provide the opportunity to tie some functions into the system that are not traditionally the sole responsibility of the personnel office (at least in most personnel offices). For example, functional alignment among various offices, work measurement, costs considerations and the like.

The system must have in its knowledge base approved functional assignments of the organizations at the activity in which it is installed (including those not serviced by the system). This will allow for the system to check for inconsistencies in functional responsibilities among offices, and allow for advice to be given in cases of overlapping functions.

The system must be able to offer advice (and perhaps provide some control) on: layering of supervision; dilution of job controlling duties among several positions; supervisory ratios; assistants and deputies; high grade considerations; average grade trends, and other such position management concerns.

In the case of upgrades on jobs, the system must make accurate judgments on job reconstitution, and allow coordination with staffing specialists in the final determination of non-competitive promotions.

As mentioned above, the actual development process of the expert system will delineate capabilities that must be built into it. I strongly urge that a development office keep in mind that the system must completely perform all tasks that would be assigned

to a classifier. Therefore, design limitations of the system must be the variety of occupations it is equipped to handle initially, rather than the full breadth of tasks that are performed by classifiers. If this approach is taken, the only performance limitation of the system would be the number of jobs it could classify, which could be added to as the system grows. This would insure a best case test of the technology, and prove its worth as a people replacement.

In order to keep the development time of the prototype within reasonable bounds, I recommend the system be initially designed to provide PM&C services to one or two organizations within an installation with from 20 to 50 occupational categories represented. Perhaps a Comptroller, or a Facility Engineer, or a Procurement Office would be appropriate. The development group will need to determine not only what occupational categories are currently present, but also occupations that may be required, and in the case of mixed jobs, those functions performed which fall into other occupational categories but are not classification controlling, and are therefore not clearly evident from a review of the existing occupations.

After the prototype is developed, it will be tested within this organization, so the organization will need to be willing to participate in the test. Before the organization is selected, its supervisors and employees will need to be thoroughly briefed on the purpose and intent of this development project. There should be no attempt to "fix" the outcome of the test by selecting only an organization that wholeheartedly agrees with the concept of expert system servicing, and by the same token an organizations should not be selected that is openly negative about the possibilities.

The number of employees in the organization is of little importance. There should be several supervisors, however, which would indicate an organization of at least 50 people.

I believe the development of the prototype should be conducted at the installation in which it will be tested. This will give the development team the opportunity to interact freely and easily with the personnel office, the target organization, and other support functions. The team must be careful not to allow local unique environmental factors to influence the development process. For example, personalities, local political relationships, purely local policies and the like should not be of any influence in the system's design.

9 ALTERNATIVES FOR DEVELOPMENT

How could Army go about building the prototype expert system? There are several approaches that could be taken, but I have boiled them down to two basic alternatives. Both of these alternatives will be described, and a recommendation will be made for the one I feel has the most merit.

Alternative #1.

This alternative would have the expert system built by a contractor under supervision from a project office staffed with personnelists. The government would develop a scope of work for the contract, use competitive bid procedures, let the contract, administer the contract as the system is built by the company, and place the system into operation at a demonstration project site. The project office would assess the capability of the system during the operational phase, either make adjustments to the system directly, or continue to work with the contractor to have him fine tune the system.

There are companies who specialize in building expert systems for customers. I have contacted several of them, and feel that an expert system could be built using this approach. There are pros and cons to utilizing this strategy which will be discussed below.

A strawman scope of work statement was prepared for use in soliciting bids from contractors to develop an expert system if this approach were selected. This statement is at Appendix K. The statement is intentionally non specific in regard to the exact processes that are used in personnel administration. I first began to spell out in detail the processes the system must mimic. For example, to spell out specifically how the system must classify a job, and which jobs it must classify. However, this activity gets into extreme minutia, that could make a statement of work read like the entire FPM, AR's, etc. It also gets into judgmental areas for which true experts need to be consulted in order to specify the parameters for expert system operation. It also depends on such things as which activity will be serviced by the system which has not been decided. Therefore, the statement of work is designed to specify outcomes of what the system must provide. Essentially, such a statement could have read "Provide an expert system that exactly mimics current functions performed by a journeyman position classification specialist". However it was felt that a scope of work would have to be a little more specific than that in order for a contractor to have some idea of what it meant. The scope of work first

needs to be agreed upon that it encompasses the functions to be included, and then a consultation is required with procurement personnel to insure it meets the standard of adequacy necessary to solicit bids.

Estimation of time frames and resources needed for the demonstration project to be brought on line in an operational mode using this alternative for development has been a very difficult area to assess. My estimates herein are based on interviews with knowledge engineers and others where expert systems have been developed, and certain assumptions about the demonstration project installation such as the number and variety of occupations involved, the amount of distributed ADP hardware (usable computer terminals) already in place, etc. The estimate is also based in part on the contractor's first phase report on the expert system being developed for military personnel functions under contract DAAK11-84-C-0083 (US Army Ballistic Research Laboratory). Assuming the scope of the system is as described above, a very rough estimate of $1.5M to $2.0M has been made for the contract to develop the prototype system. Development time would be in the neighborhood of two to three years.

A project office, directly under DA oversight will be required. The project office must have a relatively direct link to the Director of Army Civilian Personnel. This direct link is essential due to the importance of this demonstration project to the Army as a whole, and the visibility it will receive from OPM, OMB, and perhaps even the Congress. Due to the recommended installations (White Sands Missile Range, Sacramento Army Depot, or North Pacific Division, COE), all of which are in the Western US, it is recommended the project office report to the Field Office Representative at San Francisco, who in turn will report directly to the Director for this project. This concept will provide the project office access to the Civilian Personnel Center and the DA staff through the Field Representative. The Field Rep, simply by the nature of the job, has frequent contact with field operations as well as staff, and thus can easily oversee the scope of this project with both the policy levels and the operations level due to this perspective on an on-going basis.

The project office must be located at the installation at which the demonstration project will be undertaken. This gives the project office direct access to employee records, the jobs, employees and supervisors that will be serviced by the system, and the ADP environment in which the system will operate.

The project office must be staffed with a chief, two team members, and one clerical support person. The chief and the team members must be qualified personnel management specialists with broad backgrounds. They must also be conversant with ADP uses. Ideally, the team members should also be knowledgeable of expert systems technology, however based on my research, this combination of skills cannot be realistically assembled. The team

members must have a thorough background in position classification. Cost estimates of this project are based on the following staffing assumptions:

1 Chief, GM-14
2 Team Members, GS-13
1 Clerical Support, GS-6

The role of the chief is to provide overall direction to the project, plan activities of the team members, serve as contracting officer's representative overseeing the work of the contractor in the development of the expert system software, obtaining resources to conduct the demonstration project, coordinating the project with the operating CPO and activity Commander when it is brought into operation, and coordinating the project with the Field Rep, the DA staff, OPM and other interested parties. The role of the team members are to oversee specific aspects of the project such as the development of the job classification module, the position management module, and other modules required so that the system will mimic a human position classifier. Key tasks are to serve as the initial expert model for the contractor in designing the system, coordinating with other Army experts who will be used by the contractor to purify the system's performance, working out details of how different regulatory aspects will be managed by the system, and coordinating with DA and CIVPERCEN staff members on various policies which will be handled by the system. The clerical support person will provide typing, filing, telephone, and office administrative support.

Preliminary estimates on hardware/software resources required are as follows:

One mini-computer with six workstations (one for each team member and the clerk, and two for contractor personnel). It is estimated the computer must be a Symbolics, LMI or equivalent machine for programming needs by the contractor, and subsequent on-line operation of the expert system. A computer of this type runs in the neighborhood of $150K. Software required will be driven by the contractor. A tool such as KEE or ART costs around $60K to $100K.

Hardware/software final decisions will be driven, in part, by the knowledge engineer consulting firm who will actually develop the system. Preliminary contacts with companies capable of supporting this project resulted in the above estimate.

An office of at least 1500 square feet to house the project office personnel, contractor personnel, the computer and peripherals is also required at the installation hosting the demonstration project. The office must be equipped with desks, chairs, filing cabinets, etc.

The contract should also provide for contractor training of the team members in expert systems development skills and techniques.

Thus, as the contractor develops the system, the team members will become increasingly capable of expert systems development on their own. This will insure an ability to perform maintenance during the operational phase of the demonstration project.

Alternative #2.

Under this alternative, the prototype system would be built in-house with government personnel. A project office team of seven persons would be required (details covered in following chapter), equipment costs would be essentially the same as above, and time to develop would take two to three years. A field location for the team would be essential for the same reasons as cited above, and the three potential sites remain the same.

My recommendation is to develop the prototype with in-house personnel. There are drawbacks to this recommendation, but I feel the benefits outweigh them. Pros and cons for contractor vs. in-house are as follows:

With a contractor, the Army would be reasonably assured of having a professional development (from a computer technical point of view) of the prototype. There are contractors (at least a few), who have experience (albeit little) in the AI techniques necessary for the project. Utilizing in-house personnel will not assure that professionals at expert systems development will be involved. Personnel will have to be trained (covered in next chapter), and the development process will not proceed directly and smoothly from start to finish. Therefore, a more rapid prototype development with guaranteed results will probably be the result using contractor personnel, while a more methodical-while-learning development cycle will occur with in-house personnel. There are some risks that the product from in-house personnel may not be as efficient, nor as professional (code-wise) as the contractor product.

The contractor costs would be initially high, visible and known as the result of competitive procurement. In-house costs would be somewhat less, initially, not as visible (mostly salaries), and not totally known, since time factors cannot be completely controlled with personnel who are learning as they go.

In-house personnel would have a commitment to the project that is not as heavily influenced by a profit motive as the contractor. In-house personnel would provide an autonomous structure knowledgeable of the domain, and increasingly knowledgeable of knowledge engineering, while the contractor would have little commitment to become any more proficient in the knowledge domain than is required to build the system.

In-house personnel would provide a continuing resource to maintain, expand and improve upon the system at no further cost other than salaries. In contrast, a contractor developed system

may cause an "apron string" syndrome to be developed in which continuing reliance on the contractor for system maintenance, expansion and improvement would result.

Perhaps most important, since the system may well replace knowledge workers in civilian personnel functions, an in-house development effort would provide an opportunity to begin the retraining of obsoleted personnel. The "endangered species" (to quote a high placed government official) will have an opportunity to shift with the changing technology to another field of work.

My recommendation, therefore, is to proceed with development of the prototype with in-house personnel. The following chapters of this report cover this proposal in more detail.

10 PROJECT OFFICE

In this chapter I will define a recommended project office to include its size, organizational location, qualifications of personnel that will be required, and training needs for these personnel. The project office that will be described is based on the assumption that the prototype system will be developed with in-house personnel.

Qualifications of project office personnel.

Personnel assigned to the expert system project office must have unique qualifications, or the ability to assimilate the qualifications in a very short period of time. Ideally, these personnel would be qualified as both personnel generalists in the 200 series, with extensive backgrounds in position classification and computer programmers in the 334 series. Further, the qualifications in the 334 series should be in AI techniques with skills in programming in LISP. This ideal situation is not attainable immediately, since personnelists are not skilled in the 334 series, and programmers are not available with the requisite personnel experience and qualifications. It will also be difficult to find 334 personnel with AI experience.

Thus, it will be necessary to teach new skills and abilities to either personnelists or programmers. An alternate approach would be to assemble a team consisting of specialists from both disciplines. This latter alternative will be explored first.

To build a team consisting of some personnelists and some programmers and expect each disciplinary function to remain pure, i.e. the personnelists never to touch the programming environment that is the exclusive domain of the programmers, and the programmers to never deal substantively with the domain of knowledge in which they are writing code, would not work well. Turf battles would inevitably ensue, and excuses for delays or problems would always be laid at the feet of the other group. Such a concept for the project team would insure the longest development time for the project to become operational. I would strongly recommend against this approach. For those who would reject this recommendation out of hand based on the idea that specialists are required for each specialized task, I would ask them to look closely at the SCIPMIS system, and how long it has taken to get it to the archaic state that it currently exhibits.

To teach programmers to become personnelists is almost too incongruous to mention. While this might be remotely possible, given a lot of time, the credibility of the product produced by

retrained programmers would be nil.

Training personnelists to be programmers may at first seem to be a long process with a great deal of risk involved that these basically liberal arts personnel could ever learn the difficult science of computer programming. But the idea is not as far fetched as it might first appear. Evidence the microcomputer revolution that has occurred in this country since the mid-seventies. Many of these people involved in this phenomenon are not scientifically oriented people. They are basically people with inquisitive minds who begin to poke around with a microcomputer, read as much as they can get their hands on, and teach themselves the rest. Many have taught themselves how to program not only in one of the higher level languages such as BASIC and Pascal, but also the lower level, and much more difficult languages such as assembly. Learning a programming language is not all that difficult.

LISP is one of the more difficult higher level languages to learn. However, it is the programming language of choice of computer scientists for AI programming, and most expert systems have been programmed in this language. This is no accident. LISP is ideally suited to expert systems, while many of the more traditional languages such as FORTRAN are not. LISP is an object oriented language. Expert systems can best be developed with this type of language.

How would we train personnelists in LISP programming? First of all, I do not believe that the team members need to be expert LISP programmers. Elsewhere in this report recommendations are made for hardware and software to support the project office. The expert system development tool recommended takes much of the programming requirements out of process. Some LISP programming is required to supplement the tool. Writing small segments of LISP code would be required to use this tool, while the tool would take care of most of the tedium of developing the expert system. In other words, the entire expert system would not have to be LISP coded from scratch.

I believe that any member of the team must be willing to learn and have the capacity to program in LISP in order to be both productive as a personnelist on the team, and to be a hands-on worker in the development of the system software. This will best insure a product that is both professionally done from a personnel point of view, and is a computer program that does what it is supposed to do. Thus, personnelists must be selected for the project team who meet these criteria.

The Department of Navy has funded a research project at Carnegie-Mellon University that resulted in a program known as the LISP Tutor. This program does a very credible job of teaching new students to program in LISP. CMU's experience has shown that students learning LISP in the conventional classroom environment do not learn as efficiently, nor as fast as those with human tutors to help them. Thus the LISP Tutor program was developed

to replace the human tutor. This program has been shown to be nearly as efficient at teaching LISP as human tutors are, and much more effective at teaching students than traditional classroom instruction.

I contacted the Office of Naval Research, and have found that the LISP Tutor could be made available to the Department of Army. At the time of my contact, I was informed that CMU had not finished the documentation for the program, but the contract did allow the Government to use the program without royalties, or some small fee at the maximum. The final product was not expected from CMU until late June or July. I recommend Army further pursue obtaining the LISP Tutor for use in training personnelists assigned to the project office for the prototype system if this method is chosen to develop an expert system. This program will run on any VAX computer that runs under the VMS operating system.

I also recommend that the project office have one person assigned whose background is purely computer science. This person should be an accomplished LISP programmer, or one who is familiar with a number of computer languages and could quickly learn to program in LISP. This single programming specialist is required since one true expert in programming is needed to be available to the team as difficulties arise, as they most certainly will. With only one 334-type on the team, the problems associated with specialist "camps" will not occur. It will probably be difficult to find an experienced LISP programmer since they are in great demand. If one cannot be found, we should be able to find a good 334 with the interest and ability to learn LISP at a fairly rapid pace.

Size and composition of the project office.

The recommended size and composition of the team for the project office is as follows:

1 Project Office Chief, GM-201-14.. The individual must have a wide background in personnel administration, ideally having held a Personnel Officer job. The reason for this experience is to insure the prototype is developed with equal weight being placed on all functions it will perform, and insure integration of them into a cohesive whole. Expansion possibilities into other functional areas in the future must receive appropriate attention as this prototype is built. It is also important that the chief of the office be experienced at managing a function with a strong view toward service. The person should be adept at getting things done in the face of many distractions, and perhaps even in spite of popular opinion. The ability to organize, plan and evaluate are crucial to success. The successful candidate will require some background in ADP activities, and be committed to bringing about an operating demonstration project that satisfies all interests (policy makers as well as serviced employees and supervisors). This person needs to be unafraid to roll up sleeves and be a productive member of the team, to include working directly with the computer to develop the system.

2 Personnel Specialists, GS-201-13. These individuals must also have broad backgrounds in personnel, ideally in at least two functional areas. A strong position classification specialist background is essential. Since others will be brought to the team from time-to-time to serve as expert models, and for testing purposes, these people need to be willing to serve as the initial experts to build the initial system in specialized areas, but have the capacity to accept changes based on other experts inputs. As the system is "taught" its expertise, these personnelists, along with the chief, will serve as the designers of that expertise, and its user interface. They must have the ability to learn to program in LISP, and have a keen interest in computers and computer applications to the personnel business.

1 Computer Programmer, GS-334-13. This individual will ideally be an accomplished LISP programmer. Failing to find such an individual, the person must be a highly skilled programmer in other languages with a strong desire to learn LISP programming quickly and be a productive member (a LISP guru) on the team. A spirit of team cooperation is an essential personality trait.

1 Electronics Technician, GS-856-7/9/11/12. This individual will serve as the minion to the hardware. He/she will also perform a variety of other general technical tasks, and must exhibit a high degree of skill in keeping computer hardware operational, making connections of hardware items as required, and serving as the hardware interface expert for the system as it is integrated on line for supervisor's use. Some programming tasks will be performed by this person.

1 Administrative Assistant, GS-???-7/9. This individual will perform various administrative tasks including: budget preparation and administration; editorial assistance on reports, documentation, user manuals, etc.; briefing materials preparation (BASIC or Pascal programming will be required for this); preparation of specifications for procurement actions; and other tasks as required.

1 Secretary, GS-318-6. This individual will serve as the office administrator and provide clerical support to all members of the team.

While the grades of these jobs may seem high at first glance, it must be remembered that the team is working on an Army-level project that may well be used in place of many personnelists in the future. Thus, the impact of the work accomplished by the team is potentially agency-wide, and the skills, knowledges and abilities of the members of the team must be at the top end of the spectrum in order to insure a successful project is fielded.

Organizational location of project office.

There are a multitude of possibilities for this. The ultimate decision will be driven by such things as sources of funding,

influences of powerful people and the like. I am going to be so bold as to suggest how I feel it should be placed. This recommendation was previously made in the chapter 9.

An organizational wiring diagram appears in Figure 4. Because of the recommended installations at which the prototype should be developed, the San Francisco Field Office makes a logical choice for developmental oversight.

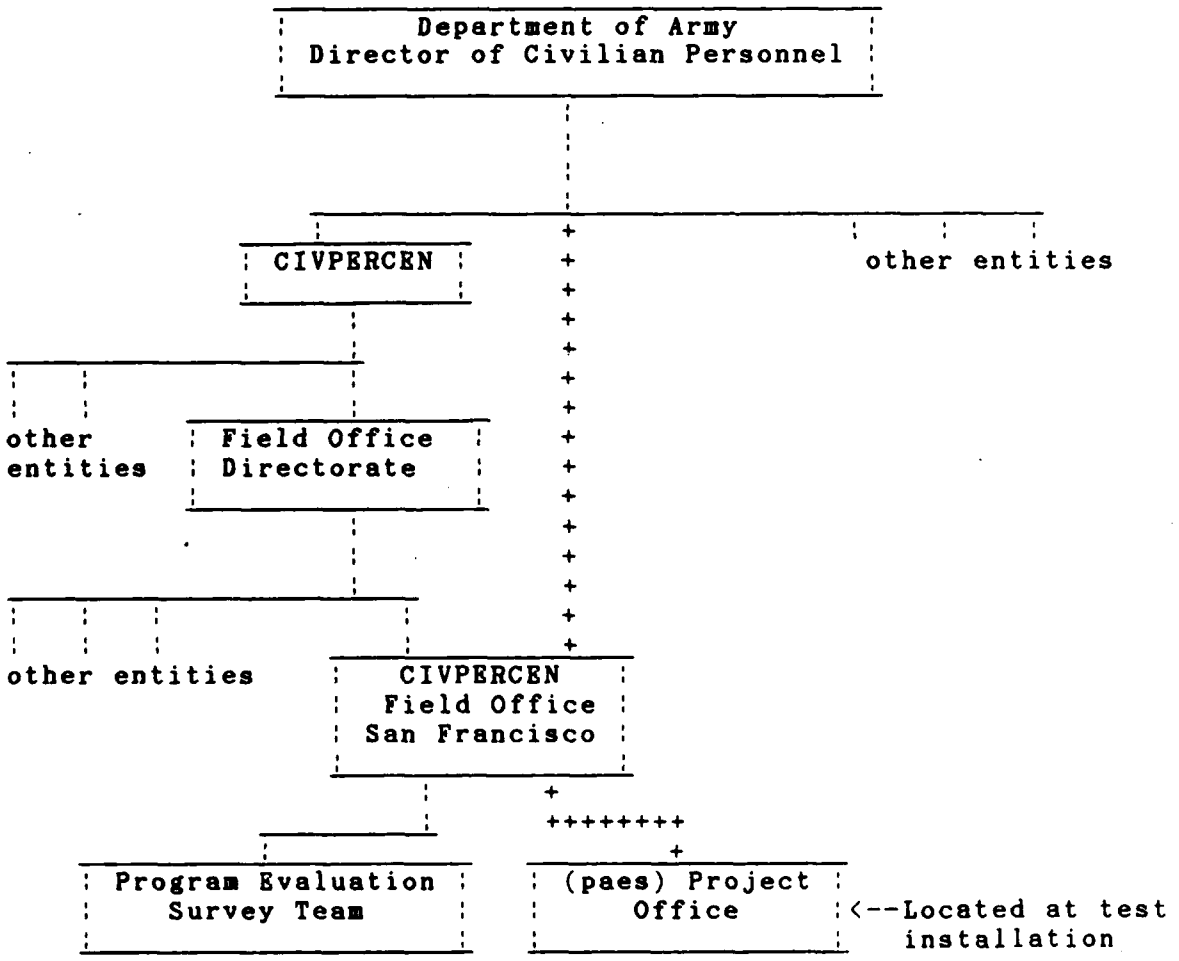


Figure 4: Organizational chart depicting the recommended placement of the project office.

A following chapter will give additional information about possible installations at which to locate the project office.

11 EQUIPMENT NEEDS

In order to build the prototype, some computer equipment will need to be obtained. Equipment can either be found within the current resources, leased, or purchased. Equipment will consist of computer hardware and software. I accomplished some preliminary investigations into the kinds, costs and availability of equipment needed to support an in-house development effort. This was accomplished to prepare cost estimates for the prototype development. If Army proceeds to pursue this effort, I recommend the project team chief, and the ADP specialist examine equipment needs in considerable detail to insure the right equipment is obtained in order to minimize any delay proper equipment might have on the prototype building endeavor. Such an analysis will probably result in some changes to these estimates.

Most expert systems are built on fairly large computers, mainframes or large minis. Expert systems demand large amounts of memory capacity, both random access and disk based. Although "toy" systems, such as the demonstration module I built on the microcomputer used on this fellowship can be built on this kind of machine, serious applications demand heavyweight computing power. Since the next stage of development is the prototype stage, and since this is still an R&D effort, I do not recommend Army invest in a large mainframe simply to build a prototype. A full working system in a standard system format would require a mainframe computer. However, at this stage of development, a prototype could be built on a less expensive machine.

The machine is driven somewhat by the software development tool that will be used for building the system. Therefore, I will first address the software issue. As mentioned in previous chapters, systems can be coded from scratch using LISP or Prolog, or some other language. However, I wouldn't recommend this approach due to several factors. First, programming in a language is very slow going. The prototype needs to be developed as rapidly as possible. Second, finding personnel, or training them to be efficient programmers to tackle the problem in this manner would be a very risky business, and consume a lot of time. And, third, system maintenance and expansion would be more laborious if a language were used.

There are tools available or the market which help to speed development time of systems and are easier to learn to use than a language. Some of them require developers to write some code, and others require no programming effort. I have looked at KEE from IntelliCorp, and ART from Inference Corp. These are very powerful development tools capable of handling the proposed

prototype. I have read a considerable amount about other tools such as EMYCIN, LOOPS, OPS5, KES, S.1, TIMM and others. They are possible candidates for this project also. Since my purpose on this project was not to select the tool to be used, I will not recommend one. Additional research by the development team would finalize the selection.

A dollar figure of about $100K has been estimated for the tool. This is will procure the software, a support package, and some training in the tool's use by the manufacturer.

These tools are implemented on various hardware systems. The powerful and recommended tools run on LISP machines, DEC-VAX machines, and others. The costs of these machines varies, of course, but I would estimate that a procurement cost of about $150K to $200K would be required for the main hardware.

I would also recommend investment in some other equipment to support the team in this phase of development. Each team member should have a microcomputer equivalent to the one used on my research project. These systems are very productive tools for the myriad of peripheral tasks that will be associated with the actual prototype development. As a matter of course, I found that I spent approximately 70% to 80% of my time at the computer on this project. This is in addition to the effort to develop the demo module in which 100% of my time was at the computer. Writing, conducting cost analysis with spreadsheets, maintaining records with the database manager, preparing briefings, and many, many tasks are performed much more efficiently and quickly using personal computers. They are clearly the "tool of the knowledge worker". Each system could be procured for about $10K to $15K and are strongly recommended. With seven people on the team, the total cost would be in the neighborhood of $70K to $100K.

A rough estimate of $300K to $400K total start-up costs for ADP equipment is envisioned.

12 THE TEST INSTALLATION

An installation will need to be selected at which to develop and test the prototype expert system. During the course of my project, I made some preliminary evaluations of possible sites. An ideal test site would have several features. It would have a very extensive distributed computer network already in place that could have this system integrated on line with existing systems. All supervisors would have access to the network, and all current standard systems (SCPIMIS, STARCIPS, budget, etc.) would be integrated into the network.

The ideal installation would also have employed a workforce of employees and supervisors who had a high degree of computer literacy, and had an understanding of expert systems and a belief in their ability to mimic human reasoning capacity. The personnel office personnel at the test installation would have an enthusiasm for automating decision processes, and would be knowledgeable of traditional computer uses. An ability to accept the basic tenants of R&D projects which cannot be totally defined at the outset, and which suffer many setbacks as the research and development progresses would be prevalent in attitudes of the installation personnel at all levels.

The geographic location of the installation would be generally desirable by people from outside the area. By this I mean that it would not have serious shortcomings or undesirable attributes that would cause potential employees of the project office to shy away from relocating there. Very high costs of living, extreme climatic conditions, remoteness from cultural, educational, social and recreational benefits are some aspects that should be avoided.

The population of the installation should be large enough so that one or two of its organizational entities could be used as the test organization without causing undue disruption to other activities at the installation. I do not anticipate the tests will cause disruption, but if a very tiny installation were selected, and the only organization of sufficient size to serve as the test was the major mission element of the activity, then potential problems could arise that might be construed as disruption.

I do not believe there are any installations within Army that satisfy all of the above "ideal" conditions.

Three installations have been identified that may come closest to these parameters. They are White Sands Missile Range, Sacramento

Army Depot, and one or more of the District Offices in the North Pacific Division, COE. Personnel office personnel at each of these activities come fairly close to criteria specified above. There seems to be enthusiasm, and acceptance of automation efforts, at least in my preliminary assessment. Each are of sufficient size to accommodate a non-disruptive test. Each are located in desirable places (WSMR may be the least of the three).

As far as good networked automation efforts are concerned, there are no Army activities that have desirable environments with the possible exception of my home installation, Yuma Proving Ground. However, Yuma is a bit small, and it is definitely not in a desirable geographical location, except for those who have lived there for awhile. Convincing others of the attractive benefits of living in the desert climate of Yuma in a fairly small city would be a very difficult task in recruitment efforts. I know, our personnel office recruiters face this problem on a daily basis. Otherwise, Yuma has made great strides on an installation wide basis at automation and distributed systems. It does not meet the ideal outlined above, but it might well be the best of the lot.

In my estimation, WSMR, NPD or Sacramento are the viable choices for hosting the development of the prototype, and I recommend the selection be from among these three, unless further analysis identifies an installation that more nearly matches the "ideal".

13 TIME-FRAMES

In this chapter I will outline an estimated time schedule for development of the PM&C prototype system. A basic assumption made is the system will be developed in-house. If the prototype were developed under contract, one might expect the times to be less since there are no time requirements for training the contractor personnel in knowledge engineering activities. Once the contractor understood the problem, he would be equipped to apply known knowledge engineering techniques to the problem at a rather rapid pace.

These estimates are gross approximations. Without having used the tools that will be required to develop the prototype, I can only guess at certain time-frames. The outline for this schedule can serve to estimate costs, and to give a development team some goals to shoot for.

Figure 5 shows an estimated milestone schedule. A task breakout of some specific milestones is included in Appendix C.

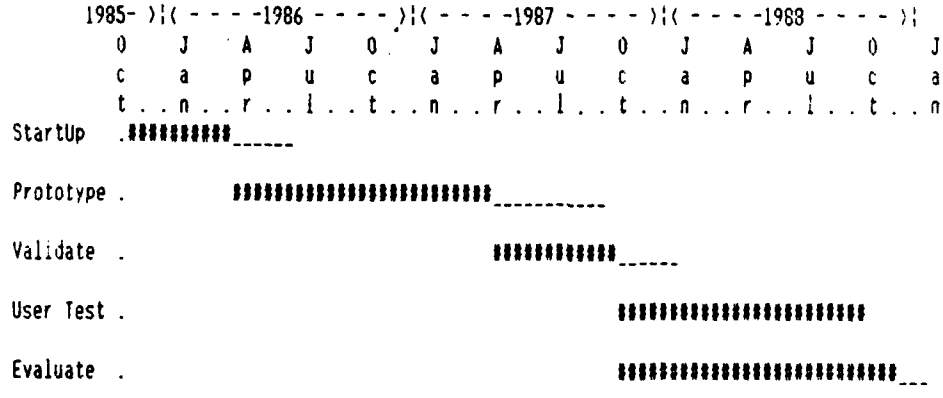


Figure 5: Milestones for prototype development.

During start-up, which would take from six to nine months, the project office would be staffed, equipment would be procured, and training on the hardware, software and knowledge engineering would begin.

During the next 12 to 18 months, the team would build the prototype system. In this stage, the team serves as both the expert and the knowledge engineer. This is the most critical

period of the project.

The validation stage, which would take six to nine months, would be the period in which other Army experts are utilized to fine-tune the prototype for use in the test organization. Experts would be borrowed from throughout Army to assess the reasoning ability of the prototype, and provide their expertise in assuring the system is drawing correct conclusions.

The next 12 months would be used in actually testing the system in operation in the test organization. Supervisors would use the system directly for the functions it had been developed to perform.

During this same period, evaluation of the system would be conducted by having parallel and identical servicing by the operating personnel office, observation of its performance by the team and Army Staff personnel, etc. (see following chapter on evaluation of expert systems). The evaluation at the conclusion of the year test phase would take about three months, and would deal with issues such as probable cost savings, overall performance of the prototype, areas for improvement, expansion, etc.

It is therefore expected that the prototype could be built and tested over a period of about three years.

14 EVALUATION OF EXPERT SYSTEMS

Because of the relative newness of this technology, expert systems in use in real world settings are not plentiful. As a consequence, there is not a great deal of information available to assess the practical benefits of their usage. It has been recognized by some that the evaluation of expert systems is vital to researchers, funders of projects, and the using world (both government and private companies) for the simple reason that expert systems, if they are viable at all, should be able to prove their worth. Those who have recognized the importance of evaluation also stress the importance of planning for the evaluation process early on, rather than wait for the project to be put into operation, and then decide how it will be evaluated.

Evaluations have been accomplished on some of the systems that are currently employed in a using environment. For example, R1, the Digital Equipment Corp. expert system used to configure VAX computers has been extensively evaluated. These evaluations have assessed not only the performance of how well it performs its task, but also other factors. On the other hand, systems such as MYCIN have been primarily evaluated only on quality of the decisions and advice rendered. Other factors such as the correctness of reasoning, the quality of the system/user interaction, efficiency and cost effectiveness have not been assessed in much detail, if at all.

This section of the report will be concerned with the critical issue of evaluation. Should further pursuit of applying expert systems technology to personnel administration be undertaken, this will outline a method of evaluation.

The several stages of implementing expert systems has been discussed in chapter 3 of this report. From the outset, when the system is initially designed, evaluation must be made a part of the top-level design. This is the stage at which the definition of long range goals are established. At the same time explicit statements of what the measures of the program's success will be and how that failure or success will be evaluated must be made. Based upon the recommendations made in this report to design a system to accomplish PM&C functions, the statements associated with this goal will now be proposed.

1. Accuracy. The system must provide a level of accuracy in its decisions and recommendations at least as accurate as those that would be rendered by human personnelists. This will be measured in several ways.

a. First, the average level of accuracy of decisions rendered by human personnelists will be measured. For example, the usual error rate of classifying jobs by personnelists in the field will serve as one measure. Their accuracy rate must be determined by a panel of experts. It is recommended Army level experts be used to assess the personnelists level of accuracy as well as the system's. (It was found in tests of MYCIN that it performed at an accuracy rate of about 75%, which at first was thought to be disappointing to the researchers who were expecting 90%. When diagnoses of diseases by experts were gathered, it was found that even they function at only a 70-80% accuracy rate.) One form of evaluation of accuracy under this scheme must be a blind type of test. For example, the panel of experts should not have knowledge of whose judgments they are assessing, personnelists or the expert system. In this manner, biases are eliminated.

b. Second, a so called gold standard will be used in those areas where it fits. A gold standard is one in which a final, objective result is measurable. For example, a gold standard exists for such a decision in personnel as the number of hours of annual leave an employee will accrue. It is based on SCD, and once calculated there is no question as to its accuracy, unless the mathematical calculation was erroneous. No subjective measures enter in as they do with judgments about the grade of a job. In the MYCIN project, a gold standard existed based on autopsies, and other objective measurements in some cases. To the extent that gold standards pertain to the prototype, they should be used.

c. Third, progressive tests to eliminate the possibility of a lack of accuracy being attributable to either non-acceptance by users, or changes in the system affecting previous abilities. What this means is, as the system is developed, experts being used to develop it must be convinced of its accuracy before placing the system into operation. Thus, if judgments rendered by the system are rejected as inaccurate by users, the inaccuracy can more readily be attributed to the user's perception, rather than a fallacy in the system. It also means that a library of cases needs to be maintained so that they can be batch processed through the system after changes are made to it. Changes to improve on one performance area in such complex systems, may cause degradation in other areas. The library cases can be utilized to test for degradations after changes are made.

2. Reasoning techniques. A methodology needs to be developed to examine the correctness of the reasoning techniques used by the expert system. It will not be acceptable if the system simply provides correct answers. The manner in which the system reached these conclusions will also need to be clearly evident, and this manner subjected to the scrutiny of experts for evaluation. For example, in both MYCIN and PROSPECTOR this kind of evaluation was not performed. If the system provided what was judged to be quality expert advice, the reasoning processes used

by the system were not questioned. Because there are so many "experts" in our business of civilian personnel administration, an ability to evaluate the techniques used by a system to infer a conclusion is critical to its success.

3. Human-computer interaction. Because of the public environment in which the system is targeted to operate, evaluation of this interface is very important. Careful and intensive planning must be brought to bear on the design of this interface, and testing and evaluation of it throughout the development of the system must be insured. It may seem difficult to formally evaluate this interface during the development phase, since the true test will not occur until the system is put into operation, and users begin to provide feedback. However, if the development phase is not conducted in the laboratory setting, but at the site where the system will be tested in an operational mode, the potential users can be brought into the development processes early on. Such important factors to consider in human-computer interaction are:

a. The choice and structure of words and phrases used in the questions and responses generated by the system.

b. The ability of the system to explain itself to the user as to why it needs certain information, or why a certain conclusion was reached. As a fielded system (paes) will certainly be used by a wide variety of people with varying degrees of knowledge of personnel administration.

c. To quote a much over-used phrase, "user friendliness", or the ability of the system to overcome users who may fear or distrust computers, especially in this field of expertise. This includes the ability of the system to assist users in the operation of the system in an interactive mode.

Bringing supervisors and employees into the project early-on as it is being developed will reap untold benefits in the changes that are made to insure a good human-computer interface, and will help to prepare the test users for actual use of the system.

4. System efficiency. The system will need to be at least as efficient as its human counterparts. In fact, a design goal should be a system several orders of magnitude greater than humans. Efficiency can be evaluated from two broad perspectives.

a. First is the perspective of technical efficiency as a computer program. This is an analysis of the program in terms of its use of CPU (central processing unit) time, its memory management efficiencies, its disk access non productive time, its judicious allocation of time to multiple users, its tight and effective code, etc. In this area of efficiency the design goals are that the system operate from one machine to service multiple users, that no obviously perceptible delays are observed by the user unless explained by the system to the user, that optimum utilization is made of the cpu, memory and disk storage media, and that system down time due to regular maintenance (backup, etc.) be no more than 3% of a 16 hour day.

b. Second is the perspective of user efficiency. I do not believe it is unreasonable to pose a design goal for this system in the area of job classification of 75 to 90 percent decrease in time to classify a job from the start of the process of a supervisor desiring to have a job classified until the job is completed.

An evaluation strategy needs to be determined early on in the development phase of the prototype lest the system be brought to use with no means of examining its worth.

15 ARMY'S EXPERTS

Expert systems cannot be built without a human expert whose knowledge, reasoning strategies and abilities are modeled in the expert system's inference engine and knowledge base. Development of all expert systems has used the approach of the knowledge engineer working with a domain expert to capture the human's expertise. In some recent cases, using software development tools, the expert himself has built the expert system. However, in all cases the human expert is essential, and as Feigenbaum has stated, nearly sufficient, to build the expert system. During the course of this research project, I undertook the task to locate Army's experts in the various specialized areas in personnel administration. I was assisted in this effort by Mr. Severin Johnson, CPO, Oakland Army Base, who made many of the follow-up contacts in search of Army's experts.

The method used to identify experts was to first make contact with Civilian Personnel Officers and Directors at all CONUS CPO's. Contact was not established with OCONUS CPO's due to the methodology which would be used, namely telephonic interviews with personnel professionals in seeking to identify experts. In this first contact, the purpose was specified, and the term "expert" was defined as "one with special knowledge representing mastery of a particular subject. Experts are also those to whom other specialists in the subject matter area go to seek advice, counsel, and solutions." If one were to try and identify experts in a purely objective manner, some form of test would have to be devised, validated, and administered to discover those who have a mastery of a subject. However, since experts are those to whom others seek counsel and solutions to difficult problems, it seemed adequate to accomplish the identification process through the method chosen.

As each personnel officer was contacted, questions were posed about whom the CPO felt was the most expert person in any particular subject matter field. An example of the interview process is presented here to show how this was done.

Q. Who do you consider to be an expert in any specialized area in our business?

A. The best person on my staff John Doe (fictitious) in staffing.

Q. What is it in the staffing area that John is expert at?

A. He really gets jobs filled in a hurry.

Q. Do you attribute his ability to get jobs filled fast to his specialized knowledge of a particular aspect of staffing? For example, is he unusually adept at reviewing a person's 171 and making a rapid and accurate assessment of qualifications?

A. No, but he really knows how to work the PPP.

Q. As far as the PPP is concerned, do you feel he knows more about it than anyone else in Army? That is, do you know anyone else, whether they work for you or not, who knows the PPP inside out and backward, so to speak, and who John might go to for advice about the PPP?

A. Yeah, well John sometimes checks with Sally Smith (fictitious) over at Zip Command when a particularly hard problem comes up. But on my staff, John is the best in this area.

Q. Do you think that as far as the PPP is concerned, you would have even more expertise available if Mary Smith were on your staff?

A. Probably.

Q. What other areas do you feel John ..... etc.

At this point, I now have a lead for a potential expert on the PPP - Mary Smith. Interviews will be held with Mary Smith's CPO, and with Mary Smith herself. The premise of this technique is that eventually we will be able to find those in CPO who are considered by others to be expert, and who themselves will recognize that they have specialized knowledges possessed by few others in DA.

143 Personnel Offices initially contacted by letter.
131 CPO's contacted by follow-up telephone interviews.
99 CPO's provided at least one name of a potential expert.

Experts Identified	Subject matter	Identified more than once
78	R&P	9
60	MER or LR	11
58	PM&C	11
27	T&D	4
26	TSO	3
22	Other	0

Table 2: Summary of data concerning Army Experts.

Time did not permit me to fully explore this search technique for all possible areas of expertise in personnel administration. By the time we got through the first round (contact with CPO's), it was becoming evident that we should build a prototype system in

DA for an expert system in one specialized area, PM&C. Therefore, we concentrated our efforts on classifiers. Results of the first tier search are summarized in Table 2.

A listing of the nominated experts is included at Appendix H of the original report only. Due to the potential sensitive nature of this information, I felt it wise to include it in only the original report.

Some further refinement of the identifications will be necessary if Army decides to pursue the development of a prototype expert system in PM&C. Since a prototype will encompass only a block of occupations in the more than 400 that exist in the Federal Government, those experts who are most knowledgeable of these occupations need to be finally identified, and their availability determined. It is not anticipated that the experts will need to be utilized for any extended period of time. Much of the development work can be accomplished by knowledgeable classifiers, and the experts be asked to examine the decision making process possessed by the prototype in order to refine and improve upon its performance. Thus the experts need only be used in a verification and refinement roll. I anticipate this to be on a strictly voluntary basis.

16 POTENTIAL FOR COST SAVINGS

In this chapter I will explore the potential for eventual cost savings by utilizing expert systems in civilian personnel administration. At this stage of the process of exploring the use of expert systems it is impossible to analyze cost savings with any degree of accuracy. There are issues which drive potential savings, or for that matter additional costs, which have not yet been decided. It is simply too early in the game to expect these issues to be decided which would give a better basis for estimating potential savings.

One of these issues is whether or not a system can be fielded which can be used directly by supervisors and employees to accomplish personnel tasks. I believe this issue is more correctly defined as: can a system be fielded which will be accepted by policy makers as being sufficient to be used directly by supervisors and employees. I am confident that a system could be built that is usable by other than personnelists. The degree to which it will satisfy policy makers that it is fully protecting ALL possible areas for manipulation by others, and that it produces identical results that under our current system may be decided on the basis of political or special interest group influences is much less confidently believed. In fact I do not believe it is possible.

Occasionally such issues as straight job classification are the result of influences that are not totally related to expert allocation of a job classification. This is not being cited as a sour grapes observation since these other influences are sometimes more important than a puristic application of rules. However, the situation is a real one, and I would be the last to tout expert systems as being able to accomplish these kinds of decision processes. They are simply too fluid to be captured in a computer program.

The vast majority of daily activities at an operating civilian personnel office do not fall into these special influence categories. However, there is the issue of system manipulation that could pose a very real threat at the operating level. If someone sets out to purposefully cheat the system, for example in the classification of a job, or the qualifications of a candidate for a position, then they will succeed. This is not to say that safeguards could not be built into the system to alert others to possible inconsistencies (cheating) by others, or to even build in safeguards that totally prevent some kinds of manipulation to be undertaken. For example, a PM&C expert system could be designed that would assess position management considerations of

"ideal" organizational structures and distribution of duties amongst positions in the "most efficient manner". Such a design would call for the system to reject any efforts to structure a job or the organization outside these parameters. Such an attempt would cause the system to notify the supervisor that he/she would need to seek human assistance in the personnel office. This, of course, may lead to chaos if everyone is trying to cheat the system as some among us believe supervisors are. Given this set of circumstances, an expert system would be more trouble than it is worth, and would result in no savings whatsoever (in fact additional costs in terms of time and the cost of system development).

Another issue of importance in assessing costs is the degree to which policy makers can accept errors. We have standards set for humans in the performance of personnel tasks. For example, Army expects a 95% job classification accuracy rate by its position classifiers (the task of assigning a title, series and grade to a set of duties). This goal is met with varying degrees of success by human classifiers. Frequently, being a subjective outcome, there are differences of OPINION as to the degree this is being successfully accomplished.

One could expect an expert system to have the same problem, depending on who is assessing the accuracy of its results. One could even expect occasional errors by a system based on fallacies in its knowledge base, inferencing techniques and the like (all fixable in a permanent way however). I do not believe one should expect an expert system to be able to provide solutions that are acceptable to ANY and ALL self proclaimed "experts". There will be differences of opinion among human experts in nearly all areas of personnel functions whether they are performed by human OR machine. I would venture to say that even after years of development and debugging, an expert system will occasionally make "errors" as judged by humans. After all, the system will be designed to mimic these same humans, and their ability to make errors.

I have made certain assumptions in this report about these issues to assess probable cost savings. These assumptions are as follows:

a. That supervisors will be entrusted not to try and be deliberately dishonest in using an expert system to accomplish personnel functions.

b. That there is some tolerance for error whether a function is performed by humans or by machines, and that this error rate is acceptable in a machine as long as it is functioning at the same level as a human.

At Appendix D there is a spreadsheet analysis of potential cost savings. This analysis is based on the number of professional personnelists, personnel assistants, and clerical personnel assigned to personnel offices both operating and staff,

worldwide. I obtained numbers of personnel for the past three years using reports that were generated by CIVPERCINS for the FORCAST group, and averaged the figures. Figures for non-200 series personnel (secretaries, clerk typists, etc.) are based on an estimate that used four operating CPO's current staffs, and projecting the ratio across the board to all personnel offices. Current costs are based on step 4 of the salary scale for the grades and number of personnel using the 1985 pay table. There are 133 operating CPO's in CONUS, 43 operating offices overseas, and 40 staff offices for a total of 216 offices worldwide.

Perhaps the most controversial aspect of this analysis is the percent replace estimate. It is here that I could not build an objective case for the number I used. My general approach at selecting this number is as follows:

There are certain functions that COULD be more amenable than others to expert systems applications in which the system performs the function of the human. I estimate that an expert system could replace all operating office position classifiers and staffing specialists (please keep in mind my assumptions above). Thus, in a full-blown expert system, supervisors would use it at the operating level to obtain job classification, position management and other functions provided by position classifiers. They would also use it to fill their jobs which would evaluate the qualifications of candidates, make referrals of best qualified, and take peripheral actions such as setting pay, making sure priority placement considerations are taken, etc. To expound on the details of each of these tasks, and how it would be done is outside the scope of this project. At this stage of research, given the fact that experimentation and development of such a system will take several years to prove or disprove any of the possibilities that exist, it would be foolhardy of me to try and prove these ideas. However, given the fact that expert systems can be developed (and have been) that perform human judgmental tasks of an equal or more difficult level, I believe it is reasonable to postulate that the potential for totally replacing operating office classifiers and staffing specialists is worth considering, and is potentially possible.

As can be seen, some of the functional specializations do not have as dramatic a potential savings figure attached. For example in the area of labor relations, there are activities performed by these specialists such as negotiations with labor unions that cannot be supplanted with a computer which would do the same thing. As mentioned in a previous chapter, expert systems could greatly assist the labor relations specialist in preparing to negotiate, and assist this human in better doing the job, but I have not attempted to assess the cost benefits of this kind of uses of expert systems. At this stage of the research process, speculation in to areas of this kind of expert systems usage is much less defensible than the notion of actually replacing people with a system that does traditional people work.

Total costs savings COULD amount to nearly $109 million per year

based on these assumptions.

I realize that there are those who are extremely uncomfortable with this kind of analysis. I would be too if the potential savings had to be totally proven and unquestionably justify further developmental efforts. Because of the very minimal amount of investment required to be able to further explore these necessarily vague potentials (which are tremendous), I believe that as a minimum, the next phase of R&D work is justified. A prototype system in the area of position classification will cost in the neighborhood of $1.5M to $3.0M (depending on what method is chosen to develop it). With a design goal of having it actually replace human classifiers, and an acceptance on the part of the policy makers of the assumptions above, hard evidence can then be gathered to support the somewhat vague potentials expressed herein. To do less, simply is not justified by the claim that total proof is required before R&D activities are initiated. We would never have explored space, never have eradicated the world of polio or a host of other things if R&D efforts had not been undertaken without provable benefits at the outset.

17 IMPACT ON PERSONNELISTS

There is a very real potential for considerable impact on currently employed and future personnelists if expert systems are utilized in the civilian personnel administration functions. If we are able to replace traditional positions performed by humans with computer systems that perform the same functions, then there exists a need to address these issues early in the planning stages from several points of view.

Some would argue that we should not employ the use of expert systems not on the basis of questioning their ability to do the rules applications functions that personnelists perform, but on the basis that some jobs are a unique combination of rules appliers, and catalysts for getting things done that do not rely solely on applying rules. There are human interactions with people that are an essential ingredient to everything personnelists do, that cannot be performed by any machine, no matter how smart it is. The human in the job makes the job what it is, not simply a system that knows all, applies all rules equally, and is painfully exact and consistent.

We have all been exposed to situations in which the ability of the person in the job to create a unique solution to a problem or the ability to apply the human touch to a particular situation was the only reason it succeeded. For example, I know a case (really not unique) in which a management employee relations specialist, with his ear to the ground, was aware of growing morale problems in an organization. They were not obvious problems such as grievances and disciplinary situations, but "rumblings" that only an astute, dedicated MER person would be aware. He was aware of the probable causes of the problem (a supervisor who was practicing favoritism with some employees), and watched the situation unfolding. There was never a reason to approach this supervisor with "assistance" since it was not serious enough to trigger such a response for the MER.

It so happened that one day a SF-52 floated into the office that would create a new kind of job for this supervisor's organization, and the MER was astute enough and knowledgeable enough of the environment that he was instantly aware that the supervisor was creating an advancement job for a favored employee. He was also aware that this would probably be the straw that would break the camel's back, and serious problems would, in all likelihood, erupt in the organization. It was also fairly obvious, that the newly created job would not raise flags to the PM&C people since it was consistent with mission and organization of the supervisor's office.

With knowledge that only a human could practically possess, the MER began to diffuse the problem before it could erupt by providing "positive management advisory services". In other words, the MER developed a strategy to prevent the situation from blowing up. I won't go into details of how, since it is irrelevant to the point I want to make. The fact is, this MER took steps to prevent a problem before it occurred. Some would argue that this is not a function of CPO. Others would argue that this was meddling on the part of the MER, and there is no proof that the undesirable outcome would have occurred had the MER left things alone.

Irrespective of which side one takes, it is clearly evident that an expert system would not have been able to accomplish what the human MER accomplished. Therefore, one could not expect to replace people with systems in which the human involvement aspect is critical. In this respect, one could argue that everything ANY personnelist is expected to do must be accomplished with an eye toward human involvement if it is justified. If this is so, then expert systems have no place in replacing personnelists in the personnel office. If it is so only on an ideal, theoretical basis (i.e. one would hope that all personnelists are at all times performing their jobs with appropriate human involvement), and in reality it is so only some of the time, then expert systems deserve the opportunity to compete with personnelists for their jobs. At least those jobs in which it is not routinely expected that personnelists will so function to a high degree of efficiency.

But what of these people who have been highly trained, integrated into the personnel administration functions so tightly, and who become excess due to the ability of the machine to replace them? Should there be an uprising of defensiveness that undermines the potential uses of expert systems so that they aren't given a chance of proving or disproving their worth? Should the threat of job loss cause those few who are marginally performing their "human only" jobs to quickly become "human" and perform those ideal functions we expect of them? Should the identifiable areas in which it is absolutely essential that humans participate control the entire nature of our functions such that there are "no areas in which the human is replaceable"?

Assuming that there are areas in which functions can be carved out to be performed by machines, there is the very real problem of what to do with excess personnel. It could be that as pieces of our business are automated, jobs are changed in such a way that they do not resemble our traditional jobs. Straight job classification may cease to exist for humans, yet there are pieces of the PM&C jobs that might not lend themselves to automation. People's thinking about what a PM&C person does would need to be radically adjusted. The PM&C person's view of his/her job would need to be likewise amended. For example, the machine classifies the job, the PM&C person is not equipped to second guess the classification, but must use the result to assist the supervisor in other areas such as position management.

If in fact the system can perform position management functions also, the PM&C person's roll changes even more dramatically.

These issues will challenge our leaders in the future if expert systems begin to become integrated into the personnel functions and take over tasks performed by personnelists. Challenges to restructure the way we conduct our business will be greater than has ever faced us in the past. I do not believe it forces us into a protectionism mode. We need neither protect the number of traditional personnelist jobs that exist today, nor protect the tasks that lend themselves to expert systems technology. People have the unique capability of adjusting to changing environments and situations. This technology in itself offers alternatives to our current jobs. All advances that have been made by mankind have somehow created opportunities for those who have the willingness to accept the challenges.

18 AN EXPERIMENT

As mentioned previously, Mr. Severin Johnson, CPO, Oakland Army Base, was detailed to work with me on this project for a period of time. He accomplished most of the work associated with locating Army experts. He also conducted the development of an expert system using Expert Ease on an experimental basis. This served two purposes. First, it helped to give insight into how quickly a professional personnelist with very little background in using computers could assimilate enough skill and ability to use the computer to do expert system development work. Second, it provided an opportunity to develop another application of this technology in the field of job classification, and dealt more extensively with GS jobs in the process. I was definitely encouraged by the results of this experiment.

Mr. Johnson chronicles his work in Appendix G. It is presented, unedited, therein.

APPENDIX A

REFERENCES

Anderson, John R., Brian J. Reiser. "The LISP Tutor." BYTE Magazine, Vol. 10, No. 4, April 1985.

Bachant, Judith, John McDermott. "R1 Revisited: Four Years in the Trenches." AI Magazine, Vol. 5, No. 3, Fall, 1984.

Barr, Avron, Edward A. Feigenbaum, Eds. The Handbook of Artificial Intelligence, Volumes I - III. William Kaufmann, Inc., Los Altos, CA, 1981.

Barstow, David. "Artificial Intelligence at Schlumberger." AI Magazine, Vol. 5, No. 4, Winter 1985.

Bierre, Pierre. "The Professor's Challenge." AI Magazine, Vol. 5, No. 4, Winter 1985.

Biggs, Rick. "Knowledge Representation in Sanskrit and Artificial Intelligence." AI Magazine, Vol. 6, No. 1, Spring 1985.

D'Ambrosio, Bruce. "Expert Systems-Myth or Reality." BYTE Magazine, Vol. 10, No. 1, January, 1985.

D'Ambrosio, Bruce. "Building Expert Systems with M.1." BYTE Magazine, Vol. 10, No. 6, June 1985.

Darany, Theodore S. "Computer Applications to Personnel (Releasing the Genie - Harnessing the Dragon)." Public Personnel Management Journal, Vol. 13, No. 4, Winter 1984.

Davis, Dwight B. "English: The Newest Computer Language." High Technology, February, 1984.

Deering, Michael F. "Architectures for AI." BYTE Magazine, Vol. 10, No. 4, April 1985.

Doherty, Michael J. "Comments on Sixth Generation Computers." Dr. Dobb's Journal, #92 June, 1984.

Doyle, Jon. "Expert Systems Without Computers Or Theory and Trust in Artificial Intelligence." AI Magazine, Vol. 5, No. 2, Summer 1984.

Faggin, Frederico. "The Challenge of Bringing New Ideas to Market." High Technology, February, 1985.

Feldman, Jerome A. "Connections." BYTE Magazine, Vol. 10, No. 4, April 1985.

Grigonis, Richard. "Sixth Generation Computers." Dr. Dobb's Journal, #91 May, 1984.

Grigonis, Richard. "And Still More Fifth Generation Computers!" Dr. Dobb's Journal, #82 August, 1983.
Harmon, Paul, David King. Expert Systems. John Wiley & Sons, New York. 1985.

Harris, Larry R. "Experience with INTELLECT: Artificial Intelligence Technology Transfer." AI Magazine, Vol. 5, No. 2, Summer 1984.

Hart, Peter E. "Artificial Intelligence in Transition." AI Magazine, Vol. 5, No. 3, Fall, 1984.

Hayes-Roth, Frederick, Donald A. Waterman, Douglas B. Lenat. Building Expert Systems. Addison-Wesley, Reading, Mass., 1983.

Hewitt, Carl. "The Challenge of Open Systems." BYTE Magazine, Vol. 10, No. 4, April 1985.

Hinton, Geoffrey E. "Learning in Parallel Networks." BYTE Magazine, Vol. 10, No. 4, April 1985.

Hollan, James D., Edwin L. Hutchins, Louis Weitzman. "STEAMER: An Interactive Inspectable Simulation-Based Training System." AI Magazine, Vol. 5, No. 2, Summer, 1984.

Kaplan, S. Jerrold. "The Industrialization of Artificial Intelligence: From By-Line to Bottom Line." AI Magazine, Vol. 5, No. 2, Summer 1984.

Katke, William. "Learning Language Using a Pattern Recognition Approach." AI Magazine, Vol. 6, No. 1, Spring 1985.

Kinnucan, Paul. "Computers that Think Like Experts." High Technology, January, 1984.

Kunz, John C., Thomas P. Kehler, Michael D. Williams. "Applications Development Using a Hybrid AI Development System." AI Magazine, Vol. 5, No. 3, Fall 1984.

Laurent, Jean-Pierre. "AI Research in France." AI Magazine, Vol. 6, No. 1, Spring 1985.

Lerner, Eric J. "Why Can't a Computer be More Like a Brain?" High Technology, August, 1984.

Martindale, Loren D. "The Case for Expert Systems in Personnel Administration." The Nick Hoag Award for Professional Development, Department of Army 1985.

McCalla, Gordon, Nick Cercone. "Artificial Intelligence in Canada: A Review." AI Magazine, Vol. 5, No. 4, Winter 1985.

Meltzer, Bernard. "Knowledge and Experience in Artificial Intelligence." AI Magazine, Vol. 6, No. 1, Spring 1985.

Michaelsen, Robert H., Donald R. Michie, Albert Boulanger. "The Technology of Expert Systems." BYTE Magazine, Vol. 10, No. 4, April 1985.

Mostow, Jack. "Toward Better Models of the Design Process." AI Magazine, Vol. 6, No. 1, April 1985.

Nilsson, Nils J. "Artificial Intelligence, Employment and Income." AI Magazine, Vol. 5, No. 2, Summer 1984.

Niwa, Kiyoshi, Koji Sasaki, Hirokazu Ihara. "An Experimental Comparison of Knowledge Representation Schemes." AI Magazine, Vol. 5, No. 2, Summer 1984.

Park, Jack. "Expert Systems and the Weather." Dr. Dobb's Journal, #90 April, 1984.

Pecora, Vincent J., Jr. "EXPRS A Prototype Expert System Using Prolog for Data Fusion." AI Magazine, Vol. 5, No. 2, Summer 1984.

Polit, Stephen. "R1 and Beyond: AI Technology Transfer at DEC." AI Magazine, Vol. 5, No. 4, Winter 1985.

Raike, William M. "The Fifth Generation in Japan." BYTE Magazine, Vol. 10, No. 4, April 1985.

Rauch, Herbert E. "Probability Concepts for an Expert System Used for Data Fusion." AI Magazine, Vol. 5, No. 3, Fall 1984.

Schank, Roger, Larry Hunter. "The Quest to Understand Thinking." BYTE Magazine, Vol. 10, No. 4, April 1985.

Smith, Reid G. "On the Development of Commercial Expert Systems." AI Magazine, Vol. 5, No. 3, Fall 1984.

Stacy, E. Webb, Ruth Ann Marco, James Hassett, Jean MacMillan, Craig Cook, Bruce Isreal, Darrell Hubbard. "The Uses of Artificial Intelligence in Military Personnel Offices." Report TR-1093-1 Prepared for U.S. Army Ballistic Research Laboratory by Scientific Systems, 1 April 1985.

Stevens, John K. "Reverse Engineering the Brain." BYTE Magazine, Vol. 10, No. 4, April 1985.

Thompson, Beverly A., William A. Thompson. "Inside an Expert System." BYTE Magazine, Vol. 10, No. 4, April 1985.

Touretzky, David S. LISP A Gentle Introduction to Symbolic Computation. Harper & Row, New York, 1984.

Weiss, Sholom M., Casimir A. Kulikowski. A Practical Guide to Designing Expert Systems. Rowman & Allanheld, Totowa, N.J., 1984.

Wasserman, Kenneth. "Physical Object Representation and Generalization: A Survey of Programs for Semantic-Based Natural Language Processing." AI Magazine, Vol. 5, No. 4, Winter 1985.

Wilensky, Robert. LISPcraft. W.W. Norton, New York, 1984.

Winston, Patrick H. "The LISP Revolution." BYTE Magazine, Vol. 10, No. 4, April 1985.

APPENDIX B

EQUIPMENT USED ON THIS PROJECT

This appendix lists and describes the software and hardware used on this project for those who may be interested. This equipment cost a total of $9,012.44. It was invaluable to me in two main ways. First it gave me the means to efficiently maintain data and information collected, and to manipulate the data in an analytical way. Since I performed my own administrative support to include typing, collecting and storing information and data, and other clerical tasks, I would not have been able to do as much without either a clerical support person, or this equipment. Second it gave me a tool to directly evaluate expert systems technology that could not have been done without the equipment. All of this equipment, with the possible exception of the Expert Ease software, can be further utilized within the Department of Army in nearly any office or shop setting. This system will continue to be a useful and productive tool to some office for years to come.

Product	Use
Compaq Plus Microcomputer	System hardware to run all software products. Also used for presenting briefings. Since it is a transportable unit, it can be taken on trips
Epson LQ-1500 Printer	Printing correspondence, reports, listings, mailing labels, programs and this report in its entirety.
Princeton Color Monitor	Development and presentation of briefings, and to provide a standard size monitor for other applications.
Wordstar Pro	Software for word processing, spelling check and indexing. (The workhorse I used most often.)
KnowledgeMan	Data Base Manager for several data bases.
SuperCalc3	Spreadsheet for analysis of numerical and costs data.
Sidekick	On-line utility program for notes calculations in Hex, ASCII tables and other programming aids.
BASICA	Programming language for briefing program, other utilities when needed.

Expert Ease	Expert system development tool for assessment of expert systems technology, and development of demonstration module.

Here is a thumbnail assessment of this equipment for any who are interested. If further details are desired, please contact me. The Compaq is a very good IBM PC compatible. It gave me no problems throughout the project, and was run for 8 to 10 hours per day. All of the software ran flawlessly on this machine with the exception of Expert Ease, which could not be copied to the hard disk. The printer worked excellently, but used ribbons up pretty fast. As you can see, this dot matrix printer puts out near letter quality print. In draft mode, it really zips along, and in LQ mode it isn't a slouch either, actually faster than most formed character printers in comparable price range. The Princeton monitor gave good graphics, and no trouble. Wordstar is an excellent wordprocessor. I have used Wordstar for several years. A bit hard to learn, but in terms of functions offered, it has no equals. Its spelling checker is fast and easy to use. The Cadillac of microcomputer wordprocessors. KnowledgeMan is difficult to learn to use, primarily because of its manual. However it is a very powerful DBMS (much more so than dBase II or III, R:Base, etc.). I wouldn't recommend it to anyone unless you are willing to struggle through the learning curve. However, if you can get your SCPMIS database downloaded to IBM PC compatible disks, then KMan is the only DBMS that can practically handle such a file. SuperCalc3 is an old favorite of mine. Probably the best spreadsheet on the market (although I haven't used Lotus 1,2,3). SC3 has justifiably received good ratings from the media, and gives good graphs in the blink of an eye. Expert Ease was assessed in the report, so I don't have anything more to say about it except that there have been new microcomputer expert system development tools introduced since this product was bought which are better and cheaper.

APPENDIX C

TIME SCHEDULE FOR PROTOTYPE DEVELOPMENT

Date	Event	Comments
Start	Project approval	Approval of project by DA, OPM, etc. Includes funds and manpower spaces approval, project site approval, reporting chain established.
Start+30	Project Officer Selected	DA selection made
Start+60	Project Officer report to project site installation.	
Start+90	Office set up, staffing of project office initiated.	Project officer to secure.
Start+150	Project office in operation, programmer position filled, ADP approval secured.	
Start+170	Procurement requisitions prepared for hardware, and software.	Ready for procurement action.
Start+180	Project officer and programmer begin crash course to learn LISP and use of expert system tool.	At appropriate sites
Start+180	Begin work on PM&C system at project site.	
Start+200	ADP hardware and software received.	
Start+320	Selections made for Personnelists-programmers, Elec Tech, Secretary.	
Start+350	Personnelists-programmers, Elec Tech, Admin Asst. and Secretary on board.	
Start+350	Other team members begin training in use of equip.	At project office and training sites

Start+450	Phase I of the PM&C prototype ready for validation.	Includes at least three GS type jobs, for which any grade can be accurately assigned by system.
Start+480	Phase I validations complete.	Other Army experts used.
Start+540	Phase II of PM&C prototype ready for validation.	Includes remainder of jobs in test organization.
Start+720	All validations complete.	
Start+720	Begin user test of system in using organization.	System capable of classifying any job in test organization
Start+720	Begin evaluation of system in use.	
Start+1080	User test complete.	
Start+1080	Begin final evaluation of prototype	
Start+1170	Final report on prototype test provided to Army.	

APPENDIX D

COST ANALYSIS - SALARIES & POTENTIAL FOR SAVINGS

	GS- 15		GS- 14		GS- 13		GS- 12	
	Number	Cost	Number	Cost	Number	Cost	Number	Cost
CPO's and PMS's								
Currently	42	2414496	100	4739200	260	10753080	200	6956200
Percent replace	10%		10%		10%		10%	
Needed w/Ex Sys	37.8	2173046.	90	4265280	234	9677772	180	6260580
Savings	4.2	241449.6	10	473920	26	1075308	20	695620
CLASSIFIERs								
Currently	4	229952	20	947840	80	3308640	255	8869155
Percent replace	50%		75%		75%		90%	
Needed w/Ex Sys	2	114976	5	236960	20	827160	25.5	886915.5
Savings	2	114976	15	710880	60	2481480	229.5	7982240.
STAFFING SPECs								
Currently	0	0	15	710880	75	3101850	270	9390870
Percent replace	%		75%		75%		90%	
Needed w/Ex Sys	0	0	3.75	177720	18.75	775462.5	27	939087
Savings	0	0	11.25	533160	56.25	2326388.	243	8451783
MGT EMP REL SPEC								
Currently	1	57488	4	189568	40	1654320	105	3652005
Percent replace	0%		75%		75%		90%	
Needed w/Ex Sys	1	57488	1	47392	10	413580	10.5	365200.5
Savings	0	0	3	142176	30	1240740	94.5	3286805.
EMPL DEV SPECs								
Currently	0	0	7	331744	40	1654320	125	4347625
Percent replace	%		75%		75%		90%	
Needed w/Ex Sys	0	0	1.75	82936	10	413580	12.5	434762.5
Savings	0	0	5.25	248808	30	1240740	112.5	3912863.
LABOR REL SPECs								
Currently	0	0	7	331744	30	1240740	75	2608575
Percent replace	%		0%		0%		50%	
Needed w/Ex Sys	0	0	7	331744	30	1240740	37.5	1304288.
Savings	0	0	0	0	0	0	37.5	1304288.

	GS- 11		GS- 9		GS- 7		GS- 5	
	Number	Cost	Number	Cost	Number	Cost	Number	Cost
CPO's and PMS's								
Currently	165	4787970	120	2878200	95	1862570	80	1266400
Percent replace	90%		90%		90%		90%	
Needed w/Ex Sys	16.5	478797	12	287820	9.5	186257	8	126640
Savings	148.5	4309173	108	2590380	85.5	1676313	72	1139760
CLASSIFIERs								
Currently	350	10156300	70	1678950	25	490150	15	237450
Percent replace	90%		90%		90%		90%	
Needed w/Ex Sys	35	1015630	7	167895	2.5	49015	1.5	23745
Savings	315	9140670	63	1511055	22.5	441135	13.5	213705
STAFFING SPECs								
Currently	420	12187560	130	3118050	45	882270	12	189960
Percent replace	90%		90%		90%		90%	
Needed w/Ex Sys	42	1218756	13	311805	4.5	88227	1.2	18996
Savings	378	10968804	117	2806245	40.5	794043	10.8	170964
MGT EMP REL SPEC								
Currently	135	3917430	25	599625	7	137242	3	47490
Percent replace	90%		90%		100%		100%	
Needed w/Ex Sys	13.5	391743	2.5	59962.5	0	0	0	0
Savings	121.5	3525687	22.5	539662.5	7	137242	3	47490
EMPL DEV SPECs								
Currently	95	2756710	30	719550	10	196060	2	31660
Percent replace	90%		90%		100%		100%	
Needed w/Ex Sys	9.5	275671	3	71955	0	0	0	0
Savings	85.5	2481039	27	647595	10	196060	2	31660
LABOR REL SPECs								
Currently	50	1450900	5	119925	2	39212	1	15830
Percent replace	50%		100%		100%		100%	
Needed w/Ex Sys	25	725450	0	0	0	0	0	0
Savings	25	725450	5	119925	2	39212	1	15830

PERS CLK & ASST	GS- 9		GS- 7		GS- 5		GS- 3	
Currently	15	359775	420	8234520	1095	17333850	740	[illegible]
Percent replace	20%		75%		75%		75%	
Needed w/Ex Sys	12	287820	105	2058630	273.75	4333463.	185	2933740
Savings	3	71955	315	6175890	821.25	13000388	555	[illegible]
OTHER CLERICAL	GS- 6		GS- 5		GS- 4		GS- 3	
Currently	45	712350	85	1345550	130	1638520	52	655400
Percent replace	5%		50%		50%		50%	
Needed w/Ex Sys	42.75	676732.5	42.5	672775	65	819260	26	327704
Savings	2.25	35617.5	42.5	672775	65	819260	26	327704

	Totals	
	Number	Cost
CPO's and PMS's		
Currently	1062	$35,658,116
Percent replace		
Needed w/Ex Sys	587.8	$23,456,192
Savings	474.2	$12,201,924
CLASSIFIERs		
Currently	819	$25,918,437
Percent replace		
Needed w/Ex Sys	98.5	$3,322,297
Savings	720.5	$22,596,141
STAFFING SPECs		
Currently	967	$29,581,440
Percent replace		
Needed w/Ex Sys	110.2	$3,530,054
Savings	856.8	$26,051,387
MGT EMP REL SPEC		
Currently	320	$10,255,168
Percent replace		
Needed w/Ex Sys	38.5	$1,335,366
Savings	281.5	$8,919,802
EMPL DEV SPECs		
Currently	309	$10,037,669
Percent replace		
Needed w/Ex Sys	36.75	$1,278,905
Savings	272.25	$8,758,765
LABOR REL SPECs		
Currently	170	$5,806,926
Percent replace		
Needed w/Ex Sys	99.5	$3,602,222
Savings	70.5	$2,204,705

	Totals	
PERS CLK & ASST	Number	Cost
Currently	2270	35255105
Percent replace		
Needed w/Ex Sys	575.75	9011653.
Savings	1694.25	26243453
OTHER CLERICAL		
Currently	312	4351828
Percent replace		
Needed w/Ex Sys	176.25	2496472.
Savings	135.75	1855357.

OVERALL SUMMARY

CURRENTLY		
Total Professionals =	3647	$117,257,756
Total all staff =	6229	$156,864,689
ESTIMATED NEEDS		
Under Expert System	1723.25	$48,033,158
POTENTIAL SAVINGS		
Under Expert System	4505.75	$108,831,531

APPENDIX E

DEMONSTRATION MODULE FILES

Printouts of files used in the Expert System Demonstration Module are included in this appendix. These files are printed out in Expert Ease format. Three printouts for each file are included. They are: Attribute listing, Examples listing and Rule listing for each Problem. See appropriate section in the report which describes how these files are used by the demo module. NOTE: Due to the large number of examples (188) used for the Air Conditioning Equipment Mechanic, its Examples listing is not included in this appendix.

EXPERT-EASE Attribute Listing, Problem: WAGE.GRAD Date: 25-feb-85

family : Which of the following best describes the major tasks assigned to this position?
maint.rpr : Maintenance or repair of equipment.
food.prep : Preparation or serving of food.
equip.opr : Operation of equipment.

cat.rpr : What type of equipment is maintained or repaired?
automotiv : Automotive (to include heavy mobile equipment).
aircond : Air Conditioning Equipment.

cat.pr : What type of equipment is operated?
mot.veh : Motor vehicles (i.e. automobiles and trucks)
fork.lft : Forklifts of any size.
crane : Cranes of any size.

class :
#food.prep :
#autom.rpr :
#mo.veh.op :
#fk.lft.op :
#crane.op :
#air.c.mec :

EXPERT-EASE Example Listing, Problem: WAGE.GRAD Date: 25-feb-85

	family logical	cat.rpr logical	cat.opr logical	class logical
1	maint.rpr	automotiv	*	#autom.rpr
2	maint.rpr	aircond	*	#air.c.mec
3	food.prep	*	*	#food.prep
4	equip.opr	*	mot.veh	#mo.veh.op
5	equip.opr	*	fork.lft	#fk.lft.op
6	equip.opr	*	crane	#crane.op

EXPERT-EASE Rule Listing, Problem: WAGE.GRAD Date: 25-feb-85

```
family
  maint.rpr : cat.rpr
       automotiv : #autom.rpr
         aircond : #air.c.mec
  food.prep : #food.prep
  equip.opr : cat.opr
          mot.veh : #mo.veh.op
         fork.lft : #fk.lft.op
            crane : #crane.op
```

EXPERT-EASE Attribute Listing. Problem: AUTOM.RPR Date: 25-feb-85

eq.kind : What kind of equipment will this employee work with?
    hv.mob.eq : Heavy mobile equipment such as bulldozers, road graders, crawler tractors, power shovels, locomotives, combat tanks, cranes, large missile transporters, and fire trucks.
    autos : Automotive equipment such as passenger cars, pick-up trucks, buses, semi-trailer truck tractors, warehouse tractors, farm tractors, fork-lifts, motorcycles, and light combat vehicles such as jeeps and trucks.

level1 : Does the employee have to have the knowledge to at least check and replace spark plugs, tail pipes, hoses and fan belts?
    smal.rpr : Yes.
    no.rpr : No.

level2 : Does this employee have to have the knowledge to at least make tune-ups on vehicles?
    tun.ups : Yes.
    no.tunup : No.

class : Sorry, the system is not yet capable of classifying
    #mob.eq.sv :
    #autc.mech :
    hv.m.eq.m : Heavy Mobile Equipment Mechanics.

	eq.kind logical	level1 logical	level2 logical	class logical
1	hv.mob.eq	no.rpr	*	#mob.eq.sv
2	hv.mob.eq	smal.rpr	no.tunup	#mob.eq.sv
3	hv.mob.eq	smal.rpr	tun.ups	hv.m.eq.m
4	autos	no.rpr	*	#mob.eq.sv
5	autos	smal.rpr	no.tunup	#mob.eq.sv
6	autos	smal.rpr	tun.ups	#auto.mech

EXPERT-EASE Rule Listing, Problem: AUTOM.RPR Date: 25-feb-85

```
level1
   smal.rpr : level2
         tun.ups : eq.kind
             hv.mob.eq : hv.a.eq.a
                 autos : #auto.mech
          no.tunup : #mob.eq.sv
      no.rpr : #mob.eq.sv
```

EXPERT-EASE Attribute Listing, Problem: MOB.EQ.SV Date: 25-feb-85

type.veh : What kind of vehicles will this employee work with?
    normal : Passenger cars and trucks (to include semis) that might, for example, stop at a hiway service station.
    heavy.eq : In addition to, or instead of the above, heavy mobile equipment such as tanks, cranes, tractors, road graders and loaders.

ext.of.svc : What is the extent of service this employee will perform?
    pump.gas : Pump gas, put water in radiator, and clean windshields ONLY.
    2greater : Provide more service, such as check oil levels and battery fluid levels.

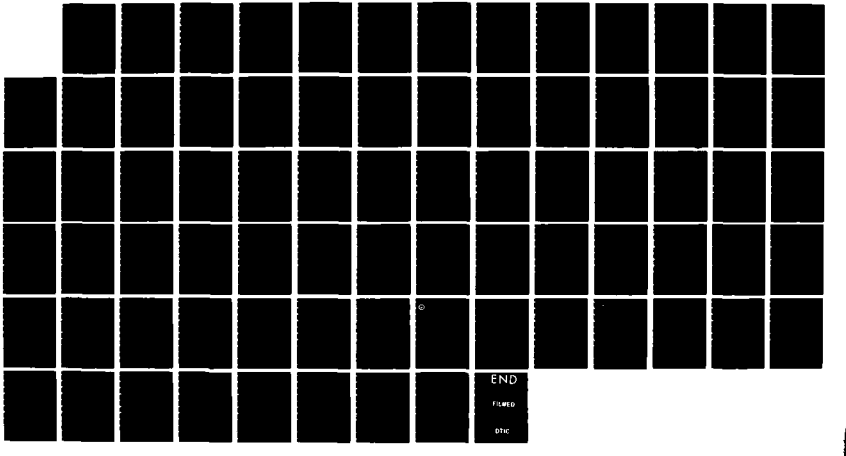
lub.tir.ch : Will this employee be expected to do such things as: repair tires, change oil, use a battery tester, check, replace and adjust such things as spark plugs, fan belts, tail pipes and hoses?
    yes : Yes, must have the knowledge to do these things.
    no : No. This kind of knowledge will not be utilized in this job.

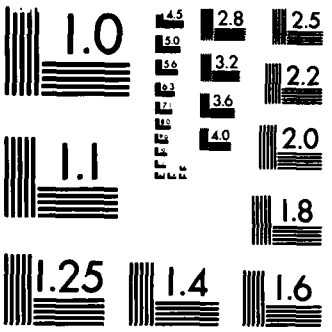
re pair : Will this employee repair vehicles by checking the condition of and replacing ANY of the following parts:
    Worn brake shoes, leaky wheel cylinders, corroded mufflers, fouled spark plugs?
    Yes. :
    NO. :

class : The classification of this job is: Mobile Equipment Servicer.
    WG-5806-01 :
    WG-5806-03 :
    WG-5806-05 :
    WG-5806-06 :
    #auto.mech :

AD-A161 025 EXPERT SYSTEMS FOR CIVILIAN PESSONNEL ADMINISTRATION (U) OFFICE OF THE DIRECTOR OF CIVILIAN PERSONNEL (ARMY) WASHINGTON DC PLANNING AND EVALUATION OFFICE 2/2

UNCLASSIFIED L D MARTINDALE 01 JUL 85 F/G 9/2 NL





EXPERT-EASE Example Listing, Problem: MOB.EQ.SV Date: 25-feb-85

	type.ven logical	ext.of.svc logical	lub.tir.ch logical	repair logical	class logical
1	normal	pump.gas	no	NO.	WG-5806-01
2	heavy.eq	pump.gas	no	NO.	WG-5806-01
3	normal	greater	no	NO.	WG-5806-03
4	normal	greater	yes	NO.	WG-5806-05
5	heavy.eq	greater	no	NO.	WG-5806-03
6	heavy.eq	greater	yes	NO.	WG-5806-06
7	normal	greater	no	Yes.	$auto.mech
8	normal	greater	yes	Yes.	$auto.mech
9	heavy.eq	greater	no	Yes.	$auto.mech
10	heavy.eq	greater	yes	Yes.	$auto.mech

EXPERT-EASE Rule Listing, Problem: MOB.EQ.SV Date: 25-feb-85

```
repair
       Yes. : #auto.mech
        NO. : ext.of.svc
         pump.gas : WG-5806-01
          greater : lub.tir.ch
                    yes : type.veh
                       normal : WG-5806-05
                     heavy.eq : WG-5806-06
                     no : WG-5806-03
```

EXPERT-EASE Attribute Listing, Problem: AUTO.MECH Date: 25-feb-85

aor.tun.up : Will the employee need to have the knowledge to do more difficult tasks than engine tune-ups?

Yes. :
No. :

test.eqip : Will the employee have to be thoroughly knowledgeable in the use of ALL of the following equipment in doing the job?

Dynamometer Oscilliscope Test Stnds Compression Guage
Exhaust Analyzer Bench Lathe Grinding and Seating Equipment

Yes. :
No. :

maj.epr : Will the employee need to be able to tear down, repair and rebuild any (or all) of the following major parts of an automobile?

Engine Transmission Clutch Differential Carburator Suspension

---

Yes. :
No. :

close.supv : As this employee does his/her job, will someone who knows how to do the job check CLOSELY on progress, and insure it is being done correctly?

Yes. :
No. :

class : The classification of this position is:

w-8 : Automotive Worker, WG-5823-08
w-10 : Automotive Mechanic, WG-5823-10
w-6 : Mobile Equipment Servicer, WG-5806-06

	maor.tun.up logical	test.eqip logical	maj.repr logical	close.supv logical	class logical
1	No.	*	*	Yes.	W-6
2	No.	*	*	No.	W-8
3	Yes.	Yes.	*	No.	W-10
4	Yes.	Yes.	*	Yes.	W-8
5	Yes.	No.	Yes.	No.	W-10
6	Yes.	No.	Yes.	Yes.	W-8
7	Yes.	No.	No.	*	W-8

```
aor.tun.up
       Yes. : close.supv
              Yes. : w-8
               No. : test.eqip
                     Yes. : w-10
                      No. : maj.repr
                            Yes. : w-10
                             No. : w-8
        No. : close.supv
              Yes. : w-6
               No. : w-8
```

EXPERT-EASE Attribute Listing, Problem: FOOD.PREP Date: 25-feb-85

grill.meat : Without detailed instructions, does the employee assist in grilling chops, steaks, poultry, and/or fish by watching while the items are cooking, turning as required, and removing when done?
    Yes. :
    No. :

ca.goods : Without detailed instructions, does the employee open and heat canned vegetables or fruits? n
    Yes. :
    No. :

grill.brek : Without detailed instructions, does the employee grill pancakes, bacon, and eggs to order?
    Ys. :
    No. :

meas.ingrd : Without detailed instructions, does the employee measure and weigh portions and ingredients as required by recepe, formula or diet?
    Yes. :
    No. :

cook.cerl : Without detailed instructions, does the employee cook cereal, beverages toast, salads, gelatin and sandwiches?
    Yes. :
    No. T, :

class :
    #cook :
    #fd.sv.wkr :

EXPERT-EASE Example Listing, Problem: FOOD.PREP Date: 25-feb-85

	grill.meat logical	can.goods logical	grill.brek logical	meas.ingrd logical	cook.cerl logical	class logical
1	Yes.	Yes.	Yes.	Y es.	Yes.	#cook
2	No.	Yes.	Yes.	Yes.	Yes.	#cook
3	Yes.	No.	Yes.	Yes.	Yes.	#cook
4	Yes.	Yes.	No.	Yes.	Yes.	#cook
5	Yes.	Yes.	Yes.	No.	Yes.	#cook
6	Yes.	Yes.	Yes.	Yes.	No.	#cook
7	*	*	*	No.	No.	#fd.sv.wkr
8	*	*	No.	No.	*	#fd.sv.wkr
9	*	No.	No.	*	*	#fd.sv.wkr
10	No.	No.	*	*	*	#fd.sv.wkr
11	No.	*	*	*	No.	#fd.sv.wkr
12	No.	*	*	No.	*	#fd.sv.wkr
13	No.	*	No.	*	*	#fd.sv.wkr
14	*	No.	*	*	No.	#fd.sv.wkr
15	*	No.	*	No.	*	#fd.sv.wkr
16	*	*	No.	*	No.	#fd.sv.wkr

EXPERT-EASE Rule Listing, Problem: FOOD.PREP Date: 25-feb-85

```
grill.meat
      Yes. : can.goods
           Yes. : grill.brek
                Yes. : meas.ingrd
                     Yes. : #cook
                      No. : cook.cerl
                           Yes. : #cook
                            No. : #fd.sv.wkr
                 No. : meas.ingrd
                      Yes. : cook.cerl
                           Yes. : #cook
                            Noo. : #fd.sv.wkr
                       No. : #fd.sv.wkr
            No. : grill.brek
                 Yes. : meas.ingrd
                      Yes. : cook.cerl
                           Yes. : #cook
                            No. : #fd.sv.wkr
                       N o. : #fd.sv.wkr
                 No. : #fd.sv.wkr
       No. : can.goods
            Yes. : grill.brek
                 Yes. : meas.ingrd
                      Yes. : cook.cerl
                           Yes. : #cook
                            No. : #fd.sv.wkr
                       cNo. : #fd.sv.wkr
                 No. : #fd.sv.wkr
            No. : #fd.sv.wkr
```

EXPERT-EASE Attribute Listing, Problem: FD.SV.WKR Date: 25-feb-85

nosp.diet : Does the employee work in a hospital or other patient care facility and do food service work related to the diets of patients?
    Yes. :
    No. :

know.diet1 : Does the employee need to know what types of foods to serve on the most common diets such as soft, bland, liquid, low caloric, low sodium, and diabetic?
    Yes. :
    No. :

know.diet2 : Will the employee need to have enough knowledge about these common modified diets to be able to answer patient questions about substitutions, or oto check a diet tray for completeness?
    Yes. :
    No. :

complx.sal : Does the employee need to know how to follow recipes and combine ingredients for complex salads and other uncooked food products?
    Yes. :
    No. :

minor.cok : Which of the following applies to this employee's job?
    recipes : Measures flour, sugar, spices, and seasonings according to complex recipes provided by the cooke or baker.
    grill : Doing a limited variety of cooking, such as grilling or frying sausage, bacon, pancakes, and eggs to order.
    neither : Neither of the above.

heavy.wk : Choose one of the following:
    fifty.lbs : Employee will frequently move objects weighing over 50 pounds.
    large.pans : Employee will do other heavy work such as scouring and scrubbing heavier cooking utensils, pots and pans, which because of their large size are unwieldy and awkward to handle.
    neither : Neither of the heavy work situations above are required of the employee.

class : The classification of this position is: Food Service Worker,
    w-1 : WG-7408-01
    w-2 : WG-7408-02
    w-3 : WG-7408-03
    w-4 : WG-7408-04

EXPERT-EASE Example Listing, Problem: FD.SV.WKR Date: 25-feb-85

	hosp.diet logical	know.diet1 logical	know.diet2 logical	complx.sal logical	minor.cok logical	heavy.wk logical	class logical
1	Yes.	Yes.	Yes.	*	*	*	w-4
2	Yes.	Yes.	No.	Yes.	recipes	*	w-4
3	Yes.	Yes.	No.	Yes.	grill	*	w-4
4	Yes.	Yes.	No.	Yes.	neither	*	w-3
5	Yes.	No.	*	Yes.	recipes	*	w-4
6	Yes.	No.	*	Yes.	grill	*	w-4
7	Yes.	No.	*	Yes.	neither	*	w-3
8	Yes.	No.	*	No.	*	fifty.lbs	w-2
9	Yes.	No.	*	No.	*	large.pans	w-2
10	Yes.	No.	*	No.	*	neither	w-1
11	No.	*	*	Yes.	recipes	*	w-4
12	No.	*	*	Yes.	grill	*	w-4
13	No.	*	*	Yes.	neither	*	w-3
14	No.	*	*	No.	*	fifty.lbs	w-2
15	No.	*	*	No.	*	large.pans	w-2
16	No.	*	*	No.	*	neither	w-1

EXPERT-EASE Rule Listing, Problem: FD.SV.WKR Date: 25-feb-85

```
compix.sal
       Yes. : minor.cok
          recipes : w-4
            grill : w-4
          neither : nosp.diet
                    Yes. : know.diet1
                           Yes. : know.diet2
                                  Yes. : w-4
                                   No. : w-3
                            No. : w-3
                     No. : w-3
        No. : heavy.wk
        fifty.lbs : nosp.diet
                    Yes. : know.diet1
                           Yes. : w-4
                            No. : w-2
                     No. : w-2
       large.pans : nosp.diet
                    Yes. : know.diet1
                           Yes. : w-4
                            No. : w-2
                     No. : w-2
          neither : nosp.diet
                    Yes. : know.diet1
                           Yes. : w-4
                            No. : w-1
            t        No. : w-1
```

EXPERT-EASE Attribute Listing, Problem: COOK Date: 25-Feb-85

supv.know : This employee works for:
    know : A higher graded cook or supervisor who knows how to do this employee's job.
    not.know : A supervisor who does not know how to do this employee's job.

lrg.variet : Does this employee cook a FULL variety of foods inclusive of ALL of the following:
Meats of all kinds Poultry Seafood Vegetables of all kinds
Numerous Sauces Gravies
    Yes. :
    No. :

many.steps : Does the employee need to know how to prepare menu items using special or difficult recipes involving many steps, or long preparation time INCLUDING but not limited to spaghetti sauce and sweet and sour pork.
    Yes. :
    No. :

on.time : Does the employee need to be skilled in the planning, coordinating and time sequencing of steps in order to have a variety of menu items being prepared simultaneously ready for serving at the same time without overcooking or waste?
    Yes. :
    No. :

adj.recipe : Does this employee need to apply knowledge and ability in adjusting recipes upward or downward in order to accommodate a different number of servings than called for in the recipe?
    Yes. :
    No. :

close.supv : Does this employee work under close supervision of another, who is normally available to answer questions about cooking, and give directions to this employee in the preparation of food?
    Yes. :
    No. :

class : This position is classified as:
    W-5 : Cook, WG-7405-05
    W-8 : Cook, WG-7404-08

EXPERT-EASE Example Listing, Problem: COOK Date: 25-feb-85

	supv.know logical	lrg.variet logical	many.steps logical	on.time logical	adj.recipe logical	close.supv logical	class logical
1	know	Yes.	Yes.	Yes.	Yes.	Yes.	w-5
2	know	Yes.	Yes.	Yes.	Yes.	No.	w-8
3	know	Yes.	Yes.	Yes.	No.	Yes.	w-5
4	know	Yes.	Yes.	Yes.	No.	No.	w-8
5	know	Yes.	Yes.	No.	Yes.	Yes.	w-5
6	know	Yes.	Yes.	No.	Yes.	No.	w-8
7	know	Yes.	Yes.	No.	No.	Yes.	w-5
8	know	Yes.	Yes.	No.	No.	No.	w-5
9	know	Yes.	No.	Yes.	Yes.	Yes.	w-5
10	know	Yes.	No.	Yes.	Yes.	No.	w-8
11	know	Yes.	No.	Yes.	No.	Yes.	w-5
12	know	Yes.	No.	Yes.	No.	No.	w-5
13	know	Yes.	No.	No.	Yes.	Yes.	w-5
14	know	Yes.	No.	No.	Yes.	No.	w-5
15	know	Yes.	No.	No.	No.	Yes.	w-5
16	know	Yes.	No.	No.	No.	No.	w-5
17	know	No.	Yes.	Yes.	Yes.	Yes.	w-5
18	know	No.	Yes.	Yes.	Yes.	No.	w-8
19	know	No.	Yes.	Yes.	No.	Yes.	w-5
20	know	No.	Yes.	Yes.	No.	No.	w-5
21	know	No.	Yes.	No.	Yes.	Yes.	w-5
22	know	No.	Yes.	No.	Yes.	No.	w-5
23	know	No.	Yes.	No.	No.	Yes.	w-5
24	know	No.	Yes.	No.	No.	No.	w-5
25	know	No.	No.	Yes.	Yes.	Yes.	w-5
26	know	No.	No.	Yes.	Yes.	No.	w-5
27	know	No.	No.	Yes.	No.	Yes.	w-5
28	know	No.	No.	Yes.	No.	No.	w-5
29	know	No.	No.	No.	Yes.	Yes.	w-5
30	know	No.	No.	No.	Yes.	No.	w-5
31	know	No.	No.	No.	No.	Yes.	w-5
32	know	No.	No.	No.	No.	No.	w-5
33	not.know	Yes.	Yes.	Yes.	Yes.	Yes.	w-5
34	not.know	Yes.	Yes.	Yes.	Yes.	No.	w-8
35	not.know	Yes.	Yes.	Yes.	No.	Yes.	w-5
36	not.know	Yes.	Yes.	Yes.	No.	No.	w-8
37	not.know	Yes.	Yes.	No.	Yes.	Yes.	w-5
38	not.know	Yes.	Yes.	No.	Yes.	No.	w-8
39	not.know	Yes.	Yes.	No.	No.	Yes.	w-5
40	not.know	Yes.	Yes.	No.	No.	No.	w-8
41	not.know	Yes.	No.	Yes.	Yes.	Yes.	w-5
42	not.know	Yes.	No.	Yes.	Yes.	No.	w-8
43	not.know	Yes.	No.	Yes.	No.	Yes.	w-5
44	not.know	Yes.	No.	Yes.	No.	No.	w-8
45	not.know	Yes.	No.	No.	Yes.	Yes.	w-5
46	not.know	Yes.	No.	No.	Yes.	No.	w-8
47	not.know	Yes.	No.	No.	No.	Yes.	w-5
48	not.know	Yes.	No.	No.	No.	No.	w-8
49	not.know	No.	Yes.	Yes.	Yes.	Yes.	w-5
50	not.know	No.	Yes.	Yes.	Yes.	No.	w-8
51	not.know	No.	Yes.	Yes.	No.	Yes.	w-5
52	not.know	No.	Yes.	Yes.	No.	No.	w-8
53	not.know	No.	Yes.	No.	Yes.	Yes.	w-5
54	not.know	No.	Yes.	No.	Yes.	No.	w-8
55	not.know	No.	Yes.	No.	No.	Yes.	w-5

	supv.know logical	lrg.variet logical	many.steps logical	on.time logical	adj.recipe logical	close.supv logical	class logical
56	not.know	No.	Yes.	No.	No.	No.	w-8
57	not.know	No.	No.	Yes.	Yes.	Yes.	w-5
58	not.know	No.	No.	Yes.	Yes.	No.	w-8
59	not.know	No.	No.	Yes.	No.	Yes.	w-5
60	not.know	No.	No.	Yes.	No.	No.	w-8
61	not.know	No.	No.	No.	Yes.	Yes.	w-5
62	not.know	No.	No.	No.	Yes.	No.	w-8
63	not.know	No.	No.	No.	No.	Yes.	w-5
64	not.know	No.	No.	No.	No.	No.	w-5

EXPERT-EASE Rule Listing, Problem: COOK Date: 25-feb-85

```
close.supv
       Yes. : w-5
        No. : supv.know
             know : irg.variet
                  Yes. : many.steps
                       Yes. : on.time
                            Yes. : w-8
                             No. : adj.recipe
                                  Yes. : w-8
                                  No. : w-5
                        No. : on.time
                             Yes. : adj.recipe
                            N        Yes. : w-8
                                     No. : w-5
                              No. : w-5
                   No. : many.steps
                       Yes. : on.time
                            Yes. : adj.recipe
                                 Yes. : w-8
                            i        No. : w-5
                              No. : w-5
                        No. : w-5
            not.know : irg.variet
                     Yes. : w-8
                      No. : many.steps
                           Yes. : w-8
                            No. : on.time
                                 Yes. : w-8
                                  No . : adj.recipe
                                       Yes. : w-8
                                        No. : w-5
```

EXPERT-EASE Attribute Listing, Problem: CRANE.OP Date: 25-feb-85

crane.typ : Two types of cranes will be referred to, bridge and boom. As used here
bridge cranes refer to those cranes which have no booms and a constant
maximum lifting capacity. Boom cranes refer to those cranes which have
booms and varying maximum lifting capacities depending upon the length,
angle, and position of the boom.
What kind of crane does this employee operate?
Bridge :
Boom :

brid.confd : Will the bridge cranebe used to move loads over and into production areas
containing equipment, machinery, supplies, and personnel?
Yes. :
No. :

pcnt.tim1 : What percent of the employee's time will the bridge crane be so operated?
(enter a number for the percent of time, e.g. 30 for thirty percent):

boom.confd : Will the boom crane be operated in any of the following situations?
Load and unload equipment and supplies on board ships.
Precision set objects such as gus into mounts, sonar equipment on to
ships, or wings on to aircraft.
n Dig and move earth or rock close to buildings, walls, or underground
obstructions.
Destroy brick and stone structures near high-voltage power lines or
e other structures.
Yes. :
No. :

pcnt.tim2 : What percent of the employee's time will the boom crane be so operated?
(enter a number for the percent of time, e.g. 30 for thirty percent):

boom.cap : Will the boom crane be operated when the crane is at or near its lifting
capacity?
Yes. :
No. :

pcnt.tim3 : What percent of the employee's time will the boom crane be so operated?
(enter a number for the percent of time, e.g. 30 for thirty percent):

class : The classification of this position is: Crane Operator,
w-7 : WG-5725-07
w-9 : WG-5725-09
w-11 : WG-5725-11

EXPERT-EASE Example Listing, Problem: CRANE.OP Date: 25-feb-85

	crane.typ logical	brid.confd logical	pcnt.tim1 integer	boom.confd logical	pcnt.tim2 integer	boom.cap logical	pcnt.tim3 integer	class logical
1	Bridge	No.	*	*	*	*	*	w-7
2	Bridge	Yes.	24	*	*	*	*	w-7
3	Bridge	Yes.	25	*	*	*	*	w-9
4	Boom	*	*	No.	*	No.	*	w-9
5	Boom	*	*	Yes.	24	No.	*	w-9
6	Boom	*	*	Yes.	25	No.	*	w-11
7	Boom	*	*	No.	*	Yes.	24	w-9
8	Boom	*	*	No.	*	Yes.	25	w-11
9	Boom	*	*	Yes.	24	Yes.	24	w-9
10	Boom	*	*	Yes.	25	Yes.	24	w-11
11	Boom	*	*	Yes.	24	Yes.	25	w-11

EXPERT-EASE Rule Listing, Problem: CRANE.OP Date: 25-feb-85

```
crane.typ
     Bridge : brid.confd
              Yes. : pcnt.tim1
                     (25 : w-7
                     )=25 : w-9
               No. : w-7
       Boom : boom.confd
              Yes. : pcnt.tim2
                     (25 : boom.cap
                          Yes. : pcnt.tim3
                                 (25 : w-9
                                 )=25 : w-11
                           No. : w-9
                     )=25 : w-11
               No. : boom.cap
                    Yes. : pcnt.tim3
                           (25 : w-9
                           )=25 : w-11
                     No. : w-9
```

EXPERT-EASE Attribute Listing, Problem: MO.VEH.OP Date: 25-feb-85

m.veh.opr : This employee will operate motor vehicles. Are ANY of the following vehicles operated by this employee?
Tanks or other tracked vehicles
Warehouse, industrial and farm tractor
Forklift trucks.
Bulldozers, graders and other earth moving and construction equipment
Road sweepers, aircraft refuelig vehicles, crash trucks, and aircraft towing vehicles.
Yes. :
.nn .. No. :

semi.truk : Is the vehicle operated a "tractor-trailer type" truck utilizing a fifth wheel or pivot for the trailer?
Yes. :
No. :

bus.opr : Is the vehicle operated by this employee a bus?
Yes. :
No. :

bus.size : What is the passenger capacity of the bus (enter a number for the maximum er of passengers the bus is designed to accommodate, e.g. 15):

typ.spec.v : What type of power takeoff equipment is on the vehicle:
wench : Wench for loading and unloading heavy materials.
trash : Trash container lifter and trash compactor BOTH OPERATED BY THIS EMPLOYEE.
other : "Cherry picker" type equipment OPERATED BY THIS EMPLOYEE.

spec.veh : Is the vehicle operated a special purpose vehicle, i.e. one with a power takeoff to power special purpose equipment on the truck?
Yes. :
No. :

gvw : Enter the gross vehicle weight of the vehicle operated (enter a number in POUNDS, e.g. 5000 for 5000 pounds):

class : The classification of this position is: Motor Vehicle Operator,
WG-5 : WG-5703-05
WG-6 : WG-5703-06
WG-7 : WG-5703-07
WG-8 : WG-5703-08
#WAGE.GRAD :

EXPERT-EASE Example Listing, Problem: MO.VEH.OP Date: 25-feb-85

	a.veh.opr logical	semi.truk logical	bus.opr logical	bus.size integer	typ.spec.v logical	spec.veh logical	gvw integer	class logical
1	Yes.	*	*	*	*	*	*	#WAGE.GRAD
2	No.	Yes.	*	*	*	*	*	w-8
3	No.	No.	Yes.	20	*	No.	*	w-6
4	No.	No.	Yes.	21	*	No.	*	w-7
5	No.	No.	No.	*	wench	Yes.	7000	w-6
6	No.	No.	No.	*	trash	Yes.	7000	w-7
7	No.	No.	No.	*	other	Yes.	7000	w-7
8	No.	No.	No.	*	*	No.	7000	w-5
9	No.	No.	No.	*	*	No.	7001	w-6
10	No.	No.	No.	*	*	No.	21999	w-6
11	No.	No.	No.	*	*	*	22000	w-7
12	No.	No.	No.	*	wench	Yes.	7001	w-6
13	No.	No.	No.	*	trash	Yes.	7001	w-7
14	No.	No.	No.	*	other	Yes.	7001	w-7
15	No.	No.	No.	*	wench	Yes.	21999	w-6
16	No.	No.	No.	*	trash	Yes.	21999	w-7
17	No.	No.	No.	*	other	Yes.	21999	w-7

```
m.veh.opr
      Yes. : #WAGE.GRAD
       No. : semi.truk
            Yes. : w-8
             No. : gvw
                 (7001 : bus.opr
                       Yes. : bus.size
                             (21 : w-6
                             )=21 : w-7
                        No. : spec.veh
                             Yes. : typ.spec.v
                                  wench : w-6
                                  trash : w-7
                                  other : w-7
                             No. : w-5
                 )=7001 : gvw
                      (22000 : spec.veh
                             Yes. : typ.spec.v
                                  wench : w-6
                                  trash : w-7
                                  other : w-7
                             No. : bus.opr
                                  Yes. : bus.size
                                        (21 : w-6
                                        )=21 : w-7
                                   No. : w-6
                           )=22000 : bus.opr
                             Yes. : bus.size
                                   (21 : w-6
                                   )=21 : w-7
                              No. : w-7
```

EXPERT-EASE Attribute Listing, Problem: FK.LFT.OP Date: 25-feb-85

load.lft : Enter the load lifting capacity of the fork lift this employee will operate (enter as a number of POUNDS, e.g. 8000 for 8000 pounds):

outside : Will the employee operate the forklift outside?
    Yes. :
    No. :

rough.ter : Is the outside terrain ROUGH, or relatively LEVEL?
    Rough :
    Level :

regular : Is it a CERTAINTY that outside operation over Rough Terrain will occur AT LEAST once in the next month?
    Yes. :
    No. :

recuring : Will operation of the forklift in rough terrain occur at scheluled regular intervals such as every day, every Friday, or other predicted intervals?
    Yes. :
    No. :

lift.cap : What is the percent of time the employee will operate this forklift to lift loads of 10,000 pounds or more? (enter as a number, e.g. 15 for 15%)
:

class : The classification of this position is: Fork Lift Operator,
    W-5 : WG-5704-05
    W-6 : WG-5704-06

EXPERT-EASE Example Listing, Problem: FK.LFT.UP Date: 25-Feb-85

	load.lft integer	outside logical	rough.ter logical	regular logical	recuring logical	lift.cap integer	class logical
1	999	No.	*	*9	*	*	w-5
2	9999	Yes.	Level	*	*	*	w-5
3	9999	Yes.	Rough	No.	*	*	w-5
4	9999	Yes.	Rough	Yes.	No.	*	w-5
5	9999	Yes.	Rough	Yes.	Yes.	*	w-6
6	10000	No.	*	*	*	24	w-5
7	10000	Yes.	Level	*	*	24	w-5
8	10000	Yes.	Rough	*	*	*	w-6
9	10000	No.	*	0 *	*	25	w-6
10	10000	Yes.	Level	*	*	25	w-6

EXPERT-EASE Rule Listing, Problem: FK.LFT.OP Date: 25-feb-85

```
load.lft
     <10000 : outside
            Yes. : rough.ter
                 Rough : regular
                       Yes. : recuring
                            Yes. : w-6
                             No. : w-5
                        No. : w-5
                 Level : w-5
             No. : w-5
     >=10000. : lift.cap
             <25 : outside
                  Yes. : rough.ter
                       Rough : w-6
                     Level : w-5
                   No. : w-5
             >=25 : w-6
```

EXPERT-EASE Attribute Listing, Problem: AIR.C.MEC Date: 25-feb-85

kind.supv : Which of the following most nearly describes the kind of supervision the employee will work under?
    independ : The employee is expected to be fully capable of performing all aspects of air conditioningmaintenance and repair with little or no technical supervisin of any kind.
    close : The employee's work is usually accomplished without immediate supervision, however, technical supervision is available when needed.

pumps :In repairing air conditioners, does this employee need to have the k so knowledge to dismantle, repair, and reassemble pumps?
    Yes. :
    No. :

impellers : Does this employee need to have the knowledge to be able to dismantle, repair, and reassemble a variety of impellers and compressors?
    Yes. :
    No. :

chillers : Does the employee need to have the knowledge to dismantle, repair, and reassemble a number of different kinds of chillers?
    Yes. :
    No. :

receivers : Is the employee expected to have the knowledge to accomplish full repair of receivers?
    Yes. :
    No. :

evaporator : Does the employee need to have extensive knowledge of the operation of evaporators in order to make complete repairs of them?
    Yes. :
    No. :

rods : Is the employee expected to have the knowledge to perform complex repairs by installing and fitting connecting rods?
    Yes. :
    No. :

crnk.shfts : Is a knowledge of installing and fitting crank shafts expected of this employee in doing the job?
    Yes. :
    No. :

pist.rings : Does the employ ee need to possess the skill and knowledge sufficient to make repairs by installing and fitting piston rings?
    Yes. :
    No. :

bearings : Is the employee expected to have the knowledge to be able to make repairs which invlove the replacement of bearings and bushings?
    Yes. :
    No. :

valves : Is knowledge of overhauling valves expected of this employee?
    Yes. :
    No. :

spec.purp : Will this employee work with special purpose air conditioning units and

systems that are used in TESTS or EXPERIMENTAL LABORATORIES, AND are used to have a DIRECT AFFECT on the tests or experiments?

Yes. :
No. :

class : This position is classified as: Air Conditioning Equipment Mechanic
w-8 : WG-5306-08
w-10 : WG-5306-10
w-11 : WG-5306-11

EXPERT-EASE Rule Listing, Problem: AIR.C.MEC Date: 25-feb-85

```
kind.supv
   independ : pumps
          Yes. : impellers
               Yes. : chillers
                    Yes. : receivers
                         Yes. : evaporator
                              Yes. : rods
                                   Yes. : crnk.shfts
                                        Yes. : spec.purp
                                             Yes. : pist.rings
                                                  Yeis. : bearings
                                                       Yes. : w-11
                                                        No. : valves
                                                             Yes. : w-11
                                                              No. : w-0
                                                   No. : bearings
                                                        Yes. : valves
                                                             Yes. : w-11
                                                              No. : w-10
                                                        No. : valves
                                                             Yes. : w-10
                                                              No. : w-8
                                        a        No. : pist.rings
                                                  Yes. : w-10
                                                   No. : bearings
                                                        Yes. : w-10
                                                         No. : valves
                                                              Yes. : w-10
                                                               No. : w-8
                                   No. : pist.rings
                                        Yes. : bearings
                                             Yes. : valves
                                                  Yes. : spec.purp
                                                       Yes. : w-11
                                                        No. : w-10
                                                  No. : w-10
                                             No. : valves
                                                  Yes. : w-10
                                                   No. : w-8
                                        No. : bearings
                                             Yes. : valves
                                                  Yes. : w-10
                                                   No. : w-8
                                             No. : w-8
                              No. : crnk.shfts
                                   Yes. : pist.rings
                                        Yes. : bearings
                                             Yes. : valves
                                                  Yes. : spec.purp
                                                       Yes. : w-11
                                                        No. : w-10
                                                  No. : w-10
                                             No. : valves
                                                  Yes. : w-10
                                                   No. : w-8
                                        No. : bearings
                                             Yes. : valves
                                                  Yes. : w-10
```

```
                                                    No. : w-8
                                                No. : w-8
                                            No. : pist.rings
                                                Yes. : bearings
                                                    Yes. : valves
                                                        Yes. : w-10
                                                        No. : w-8
                                                    No. : w-8
                                                No. : w-8
                                        No. : rods
                                            Yes. : crnk.shfts
                                                Yes. : pist.rings
                                                    Yes. : bearings
                                                        Yes. : valves
                                                            Yes. : spec.purp
                                                                Yes. : w-11
                                                                No. : w-10
                                                            No. : w-10
                                                        No. : valves
                                                            Yes. : w-10
                                                            No. : w-8
                                                    No. : bearings
                                                        Yes. : valves
                                                            Yes. : w-10
                                                            No. : w-8
                                                        No. : w-8
                                                No. : pist.rings
                                                    Yes. : bearings
                                                        Yes. : valves
                                                            Yes. : w-10
                                                            No. : w-8
                                                        No. : w-8
                                                    No. : w-8
                                            No. : crnk.shfts
                                                Yes. : pist.rings
                                                    Yes. : bearings
                                                        Yes. : valves
                                                            Yes. : w-10
                                                            No. : w-8
                                                        No. : w-8
                                                    No. : w-8
                                                No. : w-8
                                    No. : evaporator
                                        Yes. : rods
                                            Yes. : crnk.shfts
                                                Yes. : pist.rings
                                                    Yes. : bearings
                                                        Yes. : valves
                                                            Yes. : spec.purp
                                                                Yes. : w-11
                                                                No. : w-10
                                                            No. : w-10
                                                        No. : valves
                                                            Yes. : w-10
                                                            No. : w-8
                                                    No. : bearings
                                                        Yes. : valves
                                                            Yes. : w-10
```

```
                                                    No. : w-8
                                               No. : w-8
                                          No. : pist.rings
                                               Yes. : bearings
                                                    Yes. : valves
                                                         Yes. : w-10
                                                          No. : w-8
                                                    No. : w-8
                                               No. : w-8
                                     No. : crnk.shfts
                                          Yes. : pist.rings
                                               Yes. : bearings
                                                    Yes. : valves
                                                         Yes. : w-10
                                                          No. : w-8
                                                    No. : w-8
                                               No. : w-8
                                          No. : w-8
                                No. : rods
                                     Yes. : crnk.shfts
                                          Yes. : pist.rings
                                               Yes. : bearings
                                                    Yes. : valves
                                                         Yes. : w-10
                                                          No. : w-8
                                                    No. : w-8
                                               No. : w-8
                                          No. : w-8
                     No. : receivers
                          Yes. : evaporator
                               Yes. : rods
                                    Yes. : crnk.shfts
                                         Yes. : pist.rings
                                              Yes. : bearings
                                                   Yes. : valves
                                                        Yes. : spec.purp
                                                             Yes. : w-11
                                                              No. : w-10
                                                        No. : w-10
                                                   No. : valves
                                                        Yes. : w-10
                                                         No. : w-8
                                              No. : bearings
                                                   Yes. : valves
                                                        Yes. : w-10
                                                         No. : w-8
                                                   No. : w-8
                                         No. : pist.rings
                                              Yes. : bearings
                                                   Yes. : valves
                                                        Yes. : w-10
                                                         No. : w-8
                                                   No. : w-8
                                              No. : w-8
                                    No. : crnk.shfts
                                         Yes. : pist.rings
                                              Yes. : bearings
```

```
                                                    Yes. : valves
                                                         Yes. : w-10
                                                          No. : w-8
                                                    No. : w-8
                                               No. : w-8
                                          No. : w-8
                                     No. : rods
                                          Yes. : crnk.shfts
                                               Yes. : pist.rings
                                                    Yes. : bearings
                                                         Yes. : valves
                                                              Yes. : w-10
                                                               No. : w-8
                                                         No. : w-8
                                                    No. : w-8
                                               No. : w-8
                                          No. : w-8
                                No. : evaporator
                                     Yes. : rods
                                          Yes. : crnk.shfts
                                               Yes. : pist.rings
                                                    Yes. : bearings
                                                         Yes. : valves
                                                              Yes. : w-10
                                                               No. : w-8
                                                         No. : w-8
                                                    No. : w-8
                                               No. : w-8
                                          No. : w-8
                           No. : chillers
                                Yes. : receivers
                                     Yes. : evaporator
                                          Yes. : rods
                                               Yes. : crnk.shfts
                                                    Yes. : pist.rings
                                                         Yes. : bearings
                                                              Yes. : valves
                                                                   Yes. : spec.purp
                                                                        Yes. : w-11
                                                                         No. : w-10
                                                                   No. : w-10
                                                              No. : valves
                                                                   Yes. : w-10
                                                                    No. : w-8
                                                         No. : bearings
                                                              Yes. : valves
                                                                   Yes. : w-10
                                                                    No. : w-8
                                                              No. : w-8
                                                    No. : pist.rings
                                                         Yes. : bearings
                                                              Yes. : valves
                                                                   Yes. : w-10
                                                                    No. : w-8
                                                              No. : w-8
                                                         No. : w-8
                                               No. : crnk.shfts
```

```
                                        Yes. : pist.rings
                                              Yes. : bearings
                                                    Yes. : valves
                                                          Yes. : w-10
                                                           No. : w-8
                                                     No. : w-8
                                               No. : w-8
                                         No. : w-8
                                   No. : rods
                                        Yes. : crnk.shfts
                                              Yes. : pist.rings
                                                    Yes. : bearings
                                                          Yes. : valves
                                                                Yes. : w-10
                                                                 No. : w-8
                                                           No. : w-8
                                                     No. : w-8
                                               No. : w-8
                                         No. : w-8
                              No. : evaporator
                                   Yes. : rods
                                        Yes. : crnk.shfts
                                              Yes. : pist.rings
                                                    Yes. : bearings
                                                          Yes. : valves
                                                                Yes. : w-10
                                                                 No. : w-8
                                                           No. : w-8
                                                     No. : w-8
                                               No. : w-8
                                         No. : w-8
                                    No. : w-8
                         No. : receivers
                              Yes. : evaporator
                                   Yes. : rods
                                        Yes. : crnk.shfts
                                              Yes. : pist.rings
                                                    Yes. : bearings
                                                          Yes. : valves
                                                                Yes. : w-10
                                                                 No. : w-8
                                                           No. : w-8
                                                     No. : w-8
                                               No. : w-8
                                         No. : w-8
                                    No. : w-8
               No. : impellers
                    Yes. : chillers
                         Yes. : receivers
                              Yes. : evaporator
                                   Yes. : rods
                                        Yes. : crnk.shfts
                                              Yes. : pist.rings
                                                    Yes. : bearings
                                                          Yes. : valves
                                                                Yes. : spec.purp
                                                                      Yes. : w-11
```

```
                                                                    No. : w-10
                                                               No. : w-10
                                                          No. : valves
                                                               Yes. : w-10
                                                                No. : w-8
                                                     No. : bearings
                                                          Yes. : valves
                                                               Yes. : w-10
                                                                No. : w-8
                                                          No. : w-8
                                                No. : pist.rings
                                                     Yes. : bearings
                                                          Yes. : valves
                                                               Yes. : w-10
                                                                No. : w-8
                                                          No. : w-8
                                                     No. : w-8
                                           No. : crnk.shfts
                                                Yes. : pist.rings
                                                     Yes. : bearings
                                                          Yes. : valves
                                                               Yes. : w-10
                                                                No. : w-8
                                                          No. : w-8
                                                     No. : w-8
                                                No. : w-8
                                      No. : rods
                                           Yes. : crnk.shfts
                                                Yes. : pist.rings
                                                     Yes. : bearings
                                                          Yes. : valves
                                                               Yes. : w-10
                                                                No. : w-8
                                                          No. : w-8
                                                     No. : w-8
                                                No. : w-8
                                           No. : w-8
                                 No. : evaporator
                                      Yes. : rods
                                           Yes. : crnk.shfts
                                                Yes. : pist.rings
                                                     Yes. : bearings
                                                          Yes. : valves
                                                               Yes. : w-10
                                                                No. : w-8
                                                          No. : w-8
                                                     No. : w-8
                                                No. : w-8
                                           No. : w-8
                            No. : receivers
                                 Yes. : evaporator
                                      Yes. : rods
                                           Yes. : crnk.shfts
                                                Yes. : pist.rings
                                                     Yes. : bearings
                                                          Yes. : valves
                                                               Yes. : w-10
```

```
                                                    No. : w-8
                                                 No. : w-8
                                              No. : w-8
                                           No. : w-8
                                        No. : w-8
                                     No. : w-8
                                  No. : w-8
                           No. : chillers
                                Yes. : receivers
                                     Yes. : evaporator
                                          Yes. : rods
                                               Yes. : crnk.shfts
                                                    Yes. : pist.rings
                                                         Yes. : bearings
                                                              Yes. : valves
                                                                   Yes. : w-10
                                                                    No. : w-8
                                                                 No. : w-8
                                                              No. : w-8
                                                           No. : w-8
                                                        No. : w-8
                                                     No. : w-8
                                                  No. : w-8
                                               No. : w-8
                                            No. : w-8
                                         No. : w-8
                                      No. : w-8
                                   No. : w-8
                            close : w-8
```

APPENDIX F

SOURCE CODE FOR BRIEFING

This appendix contains the computer source code for a briefing prepared to explain expert systems. This briefing has been presented to two groups of personnel professionals in the Pentagon on two separate occasions, at a Western Area CPO conference, to a group of personnel from the OPM Western Region Office, and to other various small groups and individuals on numerous occasions. It is being provided in this report since it was developed during the course of the fellowship project, and the programming techniques used may be of interest to others. The program is written in BASICA from Microsoft. The time expended on writing it was somewhere between 80 and 120 hours. It employs the use of animated presentation of words and graphics and utilizes color. It has NOT been optimized for efficiency of code (I wrote as quickly as possible without concern for structure, code size or efficiency). It was also my first attempt at coding in BASICA, although I have used other versions of Microsoft BASIC which do not have many of the graphics features of BASICA.

I would be happy to discuss this technique for preparing and presenting briefings with interested persons.

```
1 '  "BRIEF513"
2 '
3 GOTO 1000
4 '
5 '
6 'Briefing on Expert Systems for Use in Army Civilian Personnel Administration
7 '
8 '
9 '
10 'From a study conducted under a
11 'Secretary of the Army Research and Study Fellowship
12 '
13 '
14 '
15 'Program written by Loren D. Martindale
16 '
17 '
18 '
19 '
20 '(c) Copyright Department of the Army and Loren D. Martindale, 1985
21 'ALL RIGHTS RESERVED
22 '
23 '
24 '
25 '
50 BKUP$=INKEY$:IF BKUP$="" THEN 50
51 RETURN
1000 CLEAR:SCREEN 1:WIDTH 40:KEY OFF:CLS:DEFINT A-Z
1002 '------- BLOCK LETTERS ---------------------------
1004 MA$="U5E10R3F10D5L3U5L17D5L3BU7BR6E5R1F5L11"
1006 MC$="H2U11E2R20F2D2L3U2L16G2D7F2R16U2R3D2G2L19"
1008 MD$="U15R20F2D11G2L20BE2BR1U11R15F2D7G2L15"
1010 ME$="U15R22D3L19D3R11D3L11D3R19D3L22"
1012 MF$="U15R22D3L19D3R11D3L11D6L3"
1014 MI$="U2R5U11L5U2R13D2L5D11R5D2L13"
1016 ML$="U15R3D13R18D2L20"
1018 MM$="U15R3F9R2E9R3D15L3U11G9L2H9D11L3"
1020 MN$="U15R3F13U13R3D15L5H11D11L3"
1022 MO$="H2U11E2R18F2D11G2L18BE2BR1H2U7E2R12F2D7G2L12"
1024 MP$="U15R20F2D6G2L16D5L3BU7BR3R13E2U2H2L13D6"
1026 MR$="U15R20F2D5G2L6F6L3H6L7D6L3BU8BR3R13E2U1H2L13D5"
1028 MS$="R16E2U3H2L16H2U2E2R14F2R2U2H2L18G2D5F3R15D3L16H2L2D2F2R3"
1030 MT$="U12L8U3R22D3L9D12L4"
1032 MV$="M-12,-15R3M+10,11M+10,-11R3M-12,15L1
1034 MY$="U5H10R3F8R2E8R3G10D5L3"
1036 DRAW"c1bm125,20;xma$;"
1038 DRAW"bm155,20;xmn$;"
1040 PAINT(126,19),1:PAINT(156,19),1
1042 '--------- LASER LOGO "EXPERT SYSTEMS" ------------
1044 '
1046 A$="M+2,-1M+2,-1M+3,-1R7"'* U L CORNER
1048 B$="R3M+2,1M+1,1D2"'* U R CORNER
1050 C$="M-1,1M-2,2M-2,1M-3,1M-3,1L4"'* L R CORNER
1052 D$="L3M-3,-1M-2,-1M-1,-1U1M+1,-1"'* L L CORNER
1054 F$="M-1,1L2M-1,1L2M+1,1R2M+1,1"'* CURVE FOR "S"
```

```
1056 E$="M+1,-1R1M+1,-1L1M+1,-1L1M-1,-1L3M-1,-1L3M-1,-1L3M-2,-1L2U3"'* CURV "S"
1058 L$="NM160,182CONM160,182C1"'* LASER ORIGIN POINT
1060
LL$="NM160,182NU4ND5NL1ONR1ONE4NF5NG5NH4CONM160,182NU4ND5NL1ONR1ONE4NF5NG5NH4C1"'**
SPARKLER ON END OF LASER
1062 ' large "E"
1064 DRAW "BM35,30;XLL$;R21;XL$;M-7,7;XL$;L17;XL$;M-3,3;XL$;R7;XL$;M-
5,5;XL$;L7;XL$;M-2,2;XL$;R17;XL$;M-6,6;XL$;L18;XD$;XL$;M+15,-
15;XL$;XA$;XL$;R20M-7,7;L17;M-3,3;R7M-5,5L7M-2,2R17M-6,6L18;XD$;"
1066 ' "X"
1068 DRAW "BM70,30;XLL$;R15;XL$;M+1,5;XL$;M+13,-5;XL$;R15;XL$;M-
26,11;XL$;M+3,12;XL$;L15;XL$;M-1,-5;XL$;M-13,5;XL$;L15;XL$;M+25,-11;XL$;M-3,-
12;XL$;R16M+1,5M+13,-5R15M-26,11M+3,12L15M-1,-5M-13,5L15M+25,-11M-3,-12"
1070 ' "P"
1072 DRAW"BM135,30;XLL$;R20;XL$;XB$;XL$;M-7,7;XL$;XC$;XL$;L11;XL$;M+5,-
5;XL$;R7;XL$;M+6,-6;XL$;L12;XL$;M-17,17;XL$;L14;XL$;M+20,-20;XL$;XA$;XL$;"
1074 DRAW"BM135,30R20;XB$;M-7,+7;XC$;L11M+5,-5R7M+6,-6L12M-17,17L14M+20,-
20;XA$;"'****** REDRAW UPPER "P"
1076 ' small "E"
1078 DRAW "BM187,30;XLL$;R21;XL$;M-7,7;XL$;L17;XL$;M-3,3;XL$;R7;XL$;M-
5,5;XL$;L7;XL$;M-2,2;XL$;R17;XL$;M-6,6;XL$;L18;XD$;XL$;M+15,-
15;XL$;XA$;XL$;R20M-7,7;L17;M-3,3;R7M-5,5L7M-2,2R17M-6,6L18;XD$;"
1080 '"R"
1082 DRAW"BM229,30;XLL$;R20;XL$;XB$;XL$;M-7,7;XL$;XC$;XL$;M+6,6;XL$;L14;XL$;M-
6,-6;XL$;L2;XL$;M-6,6;XL$;L14;XL$;M+20,-20;XL$;XA$;XL$;BM+0,6;R10;XL$;M-
6,6;XL$;L10;XL$;M+6,-6;XL$;
1084 DRAW"BM229,30R20;XB$;M-7,7;XC$;M+6,6;L14;M-6,-6;L2;M-6,6;L14;M+20,-
20;XA$;BM+0,6;R10;M-6,6;L10;M+6,-6;"
1086 ' "T"
1088 DRAW "BM270,30;XLL$;R50;XL$;M-7,7;XL$;L17;XL$;M-16,16;XL$;L15;XL$;M+16,-
16;XL$;L18;XL$;M+7,-7;XL$;R50M-7,7L17M-16,16L15M+16,-16L18M+7,-7"
1090 ' large "S"
1092 DRAW "BM25,70;XLL$;R36;XL$;M-6,6;XL$;L16;XL$;XF$;XL$;R9;XL$;XB$;XL$;M-
3,3;XL$;XC$;XL$;L32;XL$;M+6,-6;XL$;R19;XL$;XE$;XL$;M+4,-4;XL$;XA$;XL$;R30M-
6,6L16;XF$;R9;XB$;M-3,3;XC$;L32M+6,-6R19;XE$;M+4,-4;XA$;"
1094 ' "Y"
1096 DRAW "BM71,70;XLL$;R15;XL$;M+1,5;XL$;M+13,-5;XL$;R15;XL$;M-26,11;XL$;M-
12,12;XL$;L15;XL$;M+11,-12;XL$;M-2,-11;XL$;R15M+1,5M+13,-5R15M-26,11M-
12,12L15M+11,-12M-2,-11"
1098 ' small "S"
1100 DRAW "BM129,70;XLL$;R36;XL$;M-6,6;XL$;L16;XL$;XF$;XL$;R9;XL$;XB$;XL$;M-
3,3;XL$;XC$;XL$;L32;XL$;M+6,-6;XL$;R19;XL$;XE$;XL$;M+4,-4;XL$;XA$;XL$;R30M-
6,6L16;XF$;R9;XB$;M-3,3;XC$;L32M+6,-6R19;XE$;M+4,-4;XA$;"
1102 ' "T"
1104 DRAW "BM175,70;XLL$;R40;XL$;M-7,7;XL$;L12;XL$;M-16,16;XL$;L15;XL$;M+16,-
16;XL$;L13;XL$;M+7,-7;XL$;R40M-7,7L12M-16,16L15M+16,-16L13M+7,-7"
1106 ' small "E"
1108 DRAW "BM235,70;XLL$;R21;XL$;M-7,7;XL$;L17;XL$;M-3,3;XL$;R7;XL$;M-
5,5;XL$;L7;XL$;M-2,2;XL$;R17;XL$;M-6,6;XL$;L18;XD$;XL$;M+15,-
15;XL$;XA$;XL$;R20M-7,7;L17;M-3,3;R7M-5,5L7M-2,2R17M-6,6L18;XD$;M+15,-15;XA$;"
1110 ' "M"
1112 DRAW"BM275,70;XLL$;R37;XL$;XB$;XL$;M-19,19;XL$;L14;XL$;M+17,-
17;XL$;L7;XL$;M-17,17;XL$;L14;XL$;M+17,-17;XL$;NM-17,17L7;XL$;M-
17,17;XL$;L14;XL$;M+20,-20;XA$;R35;XB$;M-19,19L14M+17,-17L7M-17,17L14M+17,-
17L7M-17,17L14"
```

```
1114 ' small "S"
1116 DRAW "BM5,100;XLL$;R300;XLL$;L300R300M-6,6;XLL$;M+6,-6M-6,6L300;XLL$;M+6,-
6;XLL$;BM5,100;R300M-6,6L300M+6,-6"
1118 PAINT (31,41),1
1120 PAINT (72,35),1
1122 PAINT(140,32),1
1124 PAINT(190,32),1
1126 PAINT(235,32),1
1128 PAINT(275,32),1
1130 PAINT (30,72),1
1132 PAINT(75,72),1
1134 PAINT(132,72),1
1136 PAINT(180,72),1
1138 PAINT(240,72),1
1140 PAINT(276,72),1
1142 PAINT(10,102),2,1
1144 COLOR 14
1146 LOCATE 15,17:PRINT "F 0 R"
1148 DRAW"c2bm35,150;xmc$;"
1150 DRAW"bm70,150;xmi$;"
1152 DRAW"bm105,150;xmv$;"
1154 DRAW"bm130,150;xmi$;"
1156 DRAW"bm155,150;xml$;"
1158 DRAW"bm185,150;xmi$;"
1160 DRAW"bm210,150;xma$;"
1162 DRAW"bm245,150;xmn$;"
1164 DRAW"bm15,180;xmp$;"
1166 DRAW"bm45,180;xme$;"
1168 DRAW"bm75,180;xmr$;"
1170 DRAW"bm110,180;xms$;"
1172 DRAW"bm140,180;xmo$;"
1174 DRAW"bm170,180;xmn$;"
1176 DRAW"bm200,180;xmn$;"
1178 DRAW"bm230,180;xme$;"
1180 DRAW"bm265,180;xml$;"
1182 GOSUB 50
1199 '----- secretary of army research and study fellowship -------
1200 CLEAR
1201 MA$="U5E10R3F10D5L3U5L17D5L3BU78R6E5R1F5L11"
1202 MF$="U15R22D3L13D3R11D3L11D6L3"
1203 MR$="U15R20F2D5G2L6F6L3H6L7D6L3BU88R3R13E2U1H2L13D5"
1204 MS$="R16E2U3H2L16H2U2E2R14F2R2U2H2L18G2D5F3R15D3L16H2L2D2F2R3"
1205 CLS:COLOR 0,1
1206 DRAW"C3bm75,30xms$;":PAINT(77,29),2,3
1207 DRAW"C3bm100,30xma$;":PAINT(101,29),2,3
1208 DRAW"C3bm130,30xmr$:":PAINT(131,29),2,3
1209 DRAW"C3bm165,30xms$;":PAINT(166,29),2,3
1210 DRAW"C3bm195,30xmf$;":PAINT(196,29),2,3
1211 DIM ARS#(35),ARA#(35),ARR#(35),ARF#(35),ARB#(35)
1212 GET (65,5)-(95,35),ARS#
1213 GET(95,5)-(125,35),ARA#
1214 GET(125,5)-(155,35),ARR#
1215 GET(190,5)-(220,35),ARF#
1216 GET(125,55)-(155,85),ARB#
1217 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 1000
```

```
1218 XX%=5:FOR ZZ%=65 TO 40 STEP -1:PUT(ZZ%,XX%),ARS#,PSET:NEXT
1219 PUT(95,5),ARB#,PSET
1220 PUT(40,55),ARA#,PSET
1221 FOR Z=1 TO 500:NEXT
1222 PUT(125,5),ARB#,PSET
1223 PUT(40,85),ARR#,PSET
1224 FOR Z=1 TO 500:NEXT
1225 PUT(155,5),ARB#,PSET
1226 PUT(40,110),ARS#,PSET
1227 FOR Z=1 TO 500:NEXT
1228 PUT(190,5),ARB#,PSET
1229 PUT(40,140),ARF#,PSET
1230 FOR Z=1 TO 500:NEXT
1231 LOCATE 4,11:PRINT "E C R E T A R Y"
1232 LOCATE 6,7:PRINT "O F   T H E"
1233 LOCATE 10,11:PRINT "R M Y"
1234 LOCATE 14,11:PRINT "E S E A R C H   A N D"
1235 LOCATE 17,11:PRINT "T U D Y"
1236 LOCATE 21,11:PRINT "E L L O W S H I P"
1237 GOSUB 50
1238 COLOR 7,0
1239 LOCATE 1,1:PRINT "                                   "
1240 PRINT "                                   "
1241 PRINT "                                   "
1242 PRINT "  C O N D U C T E D   F R O M   T H E"
1243 PRINT "                                   "
1244 PRINT "                                   "
1245 PRINT "          C I V P E R C E N        "
1246 PRINT "                                   "
1247 PRINT "                                   "
1248 PRINT "       F I E L D   O F F I C E     "
1249 PRINT "                                   "
1250 PRINT "                                   "
1251 PRINT "                                   "
1252 PRINT "                 I N               "
1253 PRINT "                                   "
1254 LOCATE 17,11:PRINT "A N      "
1255 LOCATE 21,11:PRINT "R A N C I S C O     "
1256 GOSUB 50
1257 CLS
1258 DRAW"C3bm75,30xms$;":PAINT(77,29),2,3
1259 DRAW"C3bm100,30xma$;":PAINT(101,29),2,3
1260 DRAW"C3bm130,30xmr$;":PAINT(131,29),2,3
1261 DRAW"C3bm165,30xms$;":PAINT(166,29),2,3
1262 DRAW"C3bm195,30xmf$;":PAINT(196,29),2,3
1263 GOSUB 50:IF 8XUP$="B" OR 8XUP$="b" THEN 1200
1264 LOCATE 8,8:PRINT "6 MONTH PROJECT":GOSUB 50
1265 LOCATE 10,8:PRINT "FUNDED UNDER L T T":GOSUB 50
1266 LOCATE 12,10:PRINT "SALARY":GOSUB 50
1267 LOCATE 14,10:PRINT "EQUIPMENT":GOSUB 50
1268 LOCATE 16,12:PRINT "MICROCOMPUTER":GOSUB 50
1269 LOCATE 18,12:PRINT "SOFTWARE":GOSUB 50
1270 LOCATE 20,8:PRINT "ABOUT $44,000 TOTAL":GOSUB 50
1271 FOR ZZ%=12 TO 20:LOCATE ZZ%,8:PRINT "                    ":NEXT:GOSUB 50
1272 LOCATE 12,8:PRINT "EXAMINE EV-SYS TECHNOLOGY":GOSUB 50
```

```
1273 LOCATE 14,8:PRINT "IDENTIFY EXPERTS":GOSUB 50
1274 LOCATE 16,8:PRINT "CONDUCT COST ANALYSIS":GOSUB 50
1275 LOCATE 18,8:PRINT "DEVELOP DEMO MODULE OF EX-SYS":GOSUB 50
1276 LOCATE 20,8:PRINT "DEFINE DEMONSTRATION PROJECT":GOSUB 50
1300 '------ what-xsy ------------------------
1301 CLEAR:SCREEN 1:WIDTH 40:CLS:COLOR 10,0
1302 LINE (0,0)-(319,199),,B
1303 LOCATE 4,12:PRINT "W H A T   A R E
1304 LOCATE 7,5:PRINT "E X P E R T   S Y S T E M S ?
1305 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 1200
1306 LINE (1,70)-(319,70)
1307 LOCATE 12,8:PRINT "=)  Computer Programs":GOSUB 50
1308 LOCATE 12,8:PRINT " *
1309 LOCATE 14,10:PRINT "=)  Use Large Knowledge Bases":GOSUB 50
1310 LOCATE 14,10:PRINT "  "
1311 LOCATE 16,10:PRINT "=)  Rules and Inference":GOSUB 50
1312 LOCATE 16,10:PRINT "  "
1313 LOCATE 18,10:PRINT "=)  Employ Self Knowledge":GOSUB 50
1314 FOR Z%=14 TO 18:LOCATE Z%,10:PRINT "                                ":NEXT
1315 LOCATE 14,8:PRINT "=)  Simulate Experts":GOSUB 50
1316 LOCATE 14,8:PRINT " *
1317 LOCATE 16,8:PRINT "=)  Use by Non-Experts":GOSUB 50
1318 LOCATE 16,8:PRINT " *
1319 LOCATE 18,8:PRINT "=)  Give Expert Solutions":GOSUB 50
1320 LOCATE 18,8:PRINT " *
1321 '---- growing box to clear screen -----
1322 GOSUB 50
1323 X1=144:X2=170:Y1=90:Y2=110
1324 FOR Z%=1 TO 20
1325 LINE(X1,Y1)-(X2,Y2),1,BF
1326 X1=X1-8:X2=X2+8:Y1=Y1-5:Y2=Y2+5
1327 NEXT
1328 CLS:COLOR 6,1
1329 LOCATE 5,2:PRINT "H I S T O R I C A L   O V E R V I E W":GOSUB 50:IF
BKUP$="B" OR BKUP$="b" THEN 1300
1330 LOCATE 10,10:PRINT "MID-1960's AI RESEARCH":GOSUB 50
1331 LOCATE 12,10:PRINT "LAWS OF REASONING":GOSUB 50
1332 LOCATE 14,10:PRINT "POSSESSED KNOWLEDGE":GOSUB 50
1333 LOCATE 16,10:PRINT "EXPERT MODEL NECESSARY":GOSUB 50
1500 '------- practical applications --------------------
1510 CLEAR:SCREEN 1:WIDTH 40:CLS:COLOR 5,1
1511 MA$="U5E10R3F10D5L3U5L17D5L3BU7BR6E5R1F5L11"
1512 MC$="H2U11E2R20F2D2L3U2L16G2D7F2R16U2R3D2G2L19"
1513 MI$="U2R5U11L5U2R13D2L5D11R5D2L13"
1514 ML$="U15R3D13R18D2L20"
1515 MN$="U15R3F13U13R3D15L5H11D11L3"
1516 MO$="H2U11E2R18F2D11G2L18BE2BR1H2U7E2R12F2D7G2L12"
1517 MP$="U15R20F2D6G2L14D5L3BU7BR3R13E2U2H2L13D6"
1518 MR$="U15R20F2D5G2L6F6L3H6L7D6L7BU8BR3R13E2U1H2L13D5"
1519 MS$="R16E2U3H2L16H2U2E2R14F2R2G2H2L10G2D5F3R15D3L16H2L2D2F2R3"
1520 MT$="U12L3U3R22D3L9D12L4"
1521 '-------------------------------------------------------
1522 DRAW"BM25,35;XMP$;"
1524 DRAW"BM54,35;XMP$;"
1525 DRAW"BM82,35;XMA$;"
```

```
1526 DRAW"BM114,35;XMC$;"
1527 DRAW"BM152,35;XMT$;"
1528 DRAW"BM174,35;XMI$;"
1529 DRAW"BM197,35;XMC$;"
1530 DRAW"BM224,35;XMA$;"
1531 DRAW"BM256,35;XML$;"
1532 DRAW"BM5,60;XMA$;"
1533 DRAW"BM33,60;XMP$;"
1534 DRAW"BM60,60;XMP$;"
1535 DRAW"BM87,60;XML$;"
1536 DRAW"BM114,60;XMI$;"
1537 DRAW"BM134,60;XMC$;"
1538 DRAW"BM160,60;XMA$;"
1539 DRAW"BM190,60;XMT$;"
1540 DRAW"BM210,60;XMI$;"
1541 DRAW"BM232,60;XMO$;"
1542 DRAW"BM260,60;XMN$;"
1543 DRAW"BM290,60;XMS$;"
1544 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN CLEAR:GOTO 1328
1545 LOCATE 13,10:PRINT "M E D I C A L":GOSUB 50
1546 LOCATE 15,12:PRINT "MYCIN":GOSUB 50
1547 LOCATE 15,18:PRINT "- infectious disease":GOSUB 50
1548 LOCATE 17,12:PRINT "CASNET":GOSUB 50
1549 LOCATE 17,19:PRINT "- glaucoma":GOSUB 50
1550 LOCATE 19,12:PRINT "CADUCEUS":GOSUB 50
1551 LOCATE 19,21:PRINT "- internal medicine":GOSUB 50
1552 FOR ZZ%=15 TO 19:LOCATE ZZ%,12:PRINT "                              ":NEXT
1553 LOCATE 16,10:PRINT "G E O L O G I C A L":GOSUB 50
1554 LOCATE 18,12:PRINT "PROSPECTOR":GOSUB 50
1555 LOCATE 18,23:PRINT "- mineral explor":GOSUB 50
1556 LOCATE 20,12:PRINT "Dipmeter Advisor":GOSUB 50
1557 LOCATE 20,29:PRINT "- oil wells":GOSUB 50
1558 FOR ZZ%=18 TO 20:LOCATE ZZ%,12:PRINT "                              ":NEXT
1559 LOCATE 19,10:PRINT "O T H E R":GOSUB 50
1560 LOCATE 21,12:PRINT "R 1":GOSUB 50
1561 LOCATE 21,16:PRINT "- configure computers":GOSUB 50
1562 LOCATE 23,12:PRINT "DENDRAL":GOSUB 50
1563 LOCATE 23,20:PRINT "- analyze compounds":GOSUB 50
1564 FOR ZZ%=21 TO 23:LOCATE ZZ%,12:PRINT "                              ":NEXT
1565 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN CLEAR:GOTO 1510
1570 RUN 'DEMGRAPH"
2000 '     cpo budget showing 95% salary  5% other
2001 CLEAR:PI=3.141593
2002 CLS:SCREEN 1:WIDTH 40:COLOR 0,1
2003 LOCATE 2,15:PRINT "CPO BUDGET"
2004 CIRCLE(150,90),100,,,,10/18
2005 IF INKEY$="" THEN 2005
2006 CIRCLE(150,120),100,,1*PI,PI*2,10/18
2007 LINE(50,95)-(50,125)
2008 LINE(250,95)-(250,125)
2009 PAINT(150,150),2,0
2010 CIRCLE(150,90),100,0,-PI/1.2,-PI,10/18
2011 CIRCLE(150,90),100,3,-PI,-PI/1.2,10/18
2012 CIRCLE(130,88),100,,-PI/1.2,-PI,10/18
2013 LINE(50,90)-(50,115):LINE(50,115)-(50,115)
```

```
2014 LINE(130,88)-(130,90)
2015 PAINT(100,80),1,3
2016 PAINT(40,95),1,3
2017 PAINT(120,80),3,3
2018 LOCATE 11,28:PRINT "SALARIES"
2019 GOSUB 50
2020 LOCATE 13,1:PRINT "OTHER"
2021 GOSUB 50
2022 LOCATE 9,1:PRINT "TDY"
2023 LOCATE 8,1:PRINT "SUPPLIES"
2024 LOCATE 7,1:PRINT "EQUIP"
2025 GOSUB 50
2026 LOCATE 12,20:PRINT "      "
2027 LOCATE 13,20:PRINT "      "
2028 LOCATE 14,20:PRINT "      "
2029 LOCATE 13,21:PRINT "95 %
2030 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 2000
2100 '----- cpo costs  ------ growing bar chart, 3-d
2105 CLEAR
2111 M1$="U2R5U10L2E3R2D13R5D2L13"
2112 M5$="U2R18U7L18U6R20D2L17D2R17D11L20"
2113 M6$="U15R20D2L17D4R17D9L20R3BU2R14U5L14D5"
2114 MI$="U2R5U11L5U2R13D2L5D11R5D2L13"
2115 ML$="U15R3D13R18D2L20"
2116 MM$="U15R3F9R2E9R3D15L3U11G9L2H9D11L3"
2117 MDOL$="R16E2U3H2L16H2U2E2R14F2R2U2H2L18G2D5F3R15D3L16H2L2D2F2R3BM+3,-
15U3R3D3R5U3R3D3BD15D3L3U3L5D3L3U3"
2118 SCREEN 1:WIDTH 40:CLS
2119 LOCATE 1,12:PRINT "CPO COST TO ARMY":LOCATE 2,14:PRINT "($ Millions)"
2120 M=0:FOR Z%=22 TO 4 STEP -3:LOCATE Z%,1:PRINT M:M=M+20:NEXT:GOSUB 50
2121 FOR A%=170 TO 33 STEP-1:'    set row location and height of 1st bar
2122 PSET(40,A%):'                 set column location of 1st bar
2123 DRAW "c1R50c0e1c1E15":'              draw angle
2124 NEXT:'                       repeat til height is achieved
2125 DRAW"c1L50G15":LOCATE 4,8:PRINT "117.3":'   fill in top of bar
2126 LOCATE 23,7:PRINT "PROF":GOSUB 50
2127 VIEW(160,80)-(300,150),2
2128 GOSUB 50
2129 LOCATE 12,24:PRINT "GS-201 = 1062":GOSUB 50
2130 LOCATE 13,24:PRINT "GS-221 =  819":GOSUB 50
2131 LOCATE 14,24:PRINT "GS-212 =  967":GOSUB 50
2132 LOCATE 15,24:PRINT "GS-230 =  320":GOSUB 50
2133 LOCATE 16,24:PRINT "GS-235 =  309":GOSUB 50
2134 LOCATE 17,24:PRINT "GS-233 =  170":GOSUB 50
2135 LOCATE 18,24:PRINT " Total = 3647":GOSUB 50
2136 CLS
2137 VIEW
2138 '---bar 2---
2139 FOR A%=170 TO 130 STEP-1
2140 PSET(110,A%),1
2141 DRAW "C1R50c0e1c1E15"
2142 NEXT
2143 DRAW"C1L50G15":LOCATE 16,17:PRINT "35.3"
2144 LOCATE 23,15:PRINT "ADMIN":GOSUB 50
2145 '---bar 3---
```

```
2146 FOR AZ=170 TO 165 STEP-1
2147 PSET(180,AZ),2
2148 DRAW "C1R50c0e1c1E15"
2149 NEXT
2150 DRAW"C1L50G15":LOCATE 20,26:PRINT "4.4"
2151 LOCATE 23,24:PRINT "CLERK":GOSUB 50
2152 '---bar 4---
2153 FOR AZ=170 TO 160 STEP-1
2154 PSET(250,AZ),3
2155 DRAW "C2R50c0e1c2E15"
2156 NEXT
2157 DRAW"C2L50G15":LOCATE 20,35:PRINT "8.3"
2158 LOCATE 23,33:PRINT "OTHER":GOSUB 50
2159
DRAW"c3bm130,60xmdol$;bm160,60xml$;bm180,60xm6$;bm210,60xm5$;bm250,60xmm$;bm280,
60xmi$;bm297,60xml$;"
2160
PAINT(131,59),2,3:PAINT(161,59),2,3:PAINT(181,59),2,3:PAINT(211,59),2,3:PAINT(25
1,59),2,3:PAINT(281,59),2,3:PAINT(298,59),2,3:COLOR 14,0
2161 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 2100
2200 '------ (paes) logo --------
2201 CLEAR:SCREEN 1:WIDTH 80:CLS
2202 DATA "BM220,30R15BR14R15","BM70,62R18","BM310,53R23","BM184,42R16BR50R16"
2204 DATA "BM70,61R18","BM200,32R66","BM193,33R73","BM184,48R22BR38R22"
2206 DATA "BM218,58R15BR20R20","BM438,34R71","BM210,31R33BR8R15","BM308,52R22"
2208 DATA "BM450,31R55","BM511,55L70","BM441,33R69","BM70,63R18"
2210 DATA "BM184,38R30BR22R30","BM436,35R71","BM314,54R25","BM310,34R83"
2212 DATA
"BM188,34R78","BM70,65R18","BM185,35R81","BM70,64R18","BM184,43R15BR52R15"
2214 DATA "BM305,51R21","BM184,36R82","BM320,55R71","BM184,39R26BR30R26"
2216 DATA "BM501,59L64","BM184,40R22BR38R22","BM435,38R30","BM71,35R78"
2218 DATA "BM73,34R75","BM70,37R28BR27R26","BM505,58L69","BM299,44R95"
2220 DATA "BM184,44R15BR52R15","BM302,50R20","BM185,53R81","BM184,49R26BR30R26"
2222 DATA "BM299,42R30BR46R23","BM315,33R75","BM299,43R97","BM70,51R18BR4R40"
2224 DATA "BM70,48R74","BM299,45R93","BM184,52R82","BM77,69R4","BM505,50L25"
2226 DATA "BM435,36R70","BM210,57R30BR12R18","BM435,37R65","BM184,45R15BR52R15"
2228 DATA "BM184,47R18BR46R18","BM510,56L71","BM438,40R25","BM299,47R85"
2230 DATA "BM184,41R18BR46R18","BM70,49R70","BM496,60L55"
2232 DATA "BM184,50R30BR22R30","BM322,32R62","BM184,51R34BR14R34","BM70,50R66"
2234 DATA "BM511,54L65","BM70,52R18BR12R28","BM300,49R20","BM70,53R18BR19R13"
2236 DATA "BM188,54R78","BM452,44R25","BM193,55R74","BM200,56R50BR2R16"
2238 DATA "BM299,46R89","BM436,39R27","BM300,37R46BR12R41","BM508,51L25"
2240 DATA "BM70,66R18","BM445,42R25","BM184,46R16BR50R16","BM70,36R35BR13R33"
2242 DATA "BM511,53L30","BM70,40R19BR44R18","BM70,47R77","BM184,37R34BR14R34"
2244 DATA "BM345,30R15","BM70,57R18","BM330,31R45","BM350,59R37","BM508,57L71"
2246 DATA "BM441,41R25","BM71,67R16","BM70,45R35BR13R33","BM445,32R64"
2248 DATA "BM306,35R90","BM299,48R20","BM299,38R41BR25R35","BM458,30R41"
2250 DATA "BM70,44R28BR27R26","BM73,68R12","BM70,42R20BR42R19","BM70,46R79"
2252 DATA "BM299,39R37BR33R31","BM510,52L27","BM440,43R24","BM501,49L25"
2254 DATA "BM70,38R22BR38R21","BM488,61L41","BM70,39R20BR42R19","BM456,45R26"
2256 DATA "BM70,56R18","BM303,36R94","BM490,47L25","BM70,59R18","BM85,31R51"
2258 DATA "BM327,56R66","BM332,57R60","BM70,54R18","BM340,58R50","BM70,55R18"
2260 DATA "BM100,29R15","BM70,50R18","BM91,30R35","BM299,40R35BR38R28"
2262 DATA "BM495,48L24","BM80,32R63","BM76,33R70","BM299,41R32BR43R25"
2264 DATA "BM70,41R19BR44R18","BM70,60R18","BM70,43R22BR38R21","BM486,46L26"
```

```
2266 FOR ZZ=1 TO 132
2268 READ PAES$
2270 DRAW "XPAES$;"
2272 NEXT
2274 PI=3.141493
2276 FOR ZZ=100 TO 108
2278 CIRCLE(ZZ,50),80,,PI/1.5,1.33*PI
2280 NEXT
2282 FOR ZZ=480 TO 472 STEP-1
2284 CIRCLE(ZZ,50),80,,1.65*PI,PI/2.9
2286 NEXT
2288 DIM AR$(545):GET(15,19)-(565,81),AR$
2290 SCREEN 1:WIDTH 40:CLS:COLOR 5,1
2292 PUT(7,19),AR$
2294 LOCATE 15,7:PRINT "A PERSONNEL ADMINISTRATION"
2296 LOCATE 17,13:PRINT "EXPERT SYSTEM"
2298 LOCATE 19,7:PRINT "FOR THE DEPARTMENT OF ARMY"
2299 GOSUB 50
2300 '---- paes, full blown system ------
2302 CLEAR:SCREEN 1:WIDTH 40:CLS:COLOR 6,1
2304 LOCATE 2,9:PRINT "TOTAL (paes) OPERATION":GOSUB 50:IF BKUP$="B" OR
BKUP$="b" THEN 2200
2306 LOCATE 7,5:PRINT "Cover ALL Functions"
2308 FOR Z=1 TO 5:LOCATE 7,2:PRINT "  ":FOR ZZ=1 TO 200:NEXT:LOCATE 7,2:PRINT
":)":FOR ZZ=1 TO 300:NEXT:NEXT:GOSUB 50:LOCATE 7,2:PRINT " *"
2310 LOCATE 10,5:PRINT "Directly Operated by Supv/Empl"
2312 FOR Z=1 TO 5:LOCATE 10,2:PRINT "  ":FOR ZZ=1 TO 200:NEXT:LOCATE 10,2:PRINT
":)":FOR ZZ=1 TO 300:NEXT:NEXT:GOSUB 50:LOCATE 10,2:PRINT " *"
2314 LOCATE 13,5:PRINT "Decisions Made by (paes)"
2316 FOR Z=1 TO 5:LOCATE 13,2:PRINT "  ":FOR ZZ=1 TO 200:NEXT:LOCATE 13,2:PRINT
":)":FOR ZZ=1 TO 300:NEXT:NEXT:GOSUB 50:LOCATE 13,2:PRINT " *"
2318 LOCATE 16,5:PRINT "Appropriate Actions Taken by (paes)"
2320 FOR Z=1 TO 5:LOCATE 16,2:PRINT "  ":FOR ZZ=1 TO 200:NEXT:LOCATE 16,2:PRINT
":)":FOR ZZ=1 TO 300:NEXT:NEXT:GOSUB 50:LOCATE 16,2:PRINT " *"
2322 CLS:COLOR 0
2324 LOCATE 1,16:PRINT "EXAMPLE":GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 2300
2326 LINE(0,10)-(60,35),2,BF
2328 LOCATE 4,9:PRINT "Superv gets new manpower auth":GOSUB 50
2330 LOCATE 4,9:PRINT "
2332 LOCATE 3,3:PRINT "New":LOCATE 4,3:PRINT "Job"
2334 DRAW"c1bm30,36d13r1u13l2d13h4r8g4"
2336 LINE(0,50)-(60,75),2,BF
2338 LOCATE 9,9:PRINT "Use (paes) from ofc terminal":GOSUB 50
2340 LOCATE 9,9:PRINT "
2342 LOCATE 8,2:PRINT "Access":LOCATE 9,2:PRINT "(paes)"
2344 DRAW"c1bm30,76d13r1u13l2d13h4r8g4"
2346 LINE(0,90)-(60,115),2,BF
2348 LOCATE 14,9:PRINT "(paes) prompts supv for info":GOSUB 50
2350 LOCATE 14,9:PRINT "
2352 LOCATE 13,2:PRINT "(paes)":LOCATE 14,2:PRINT "Prompt"
2354 DRAW"c1bm30,116d13r1u13l2d13h4r8g4"
2356 LINE(0,130)-(60,155),2,BF
2358 LOCATE 19,9:PRINT "Superv responds with input":GOSUB 50
2360 LOCATE 19,9:PRINT "
2362 LOCATE 18,3:PRINT "Supv":LOCATE 19,2:PRINT "Replys"
```

```
2364 DRAW"c1bm61,142r15u40r1d40r1u40l17e4d8h4"
2366 LOCATE 16,11:PRINT "Interaction":GOSUB 50
2368 LOCATE 16,11:PRINT "                "
2370 DRAW"c0bm61,142r15u40r1d40r1u40l17e4d8h4"
2372 DRAW"c1bm30,156d13r1u13l2d13h4r8g4"
2374 LINE(0,170)-(60,195),2,BF
2376 LOCATE 24,9:PRINT "(paes) decides classification";:GOSUB 50
2378 LOCATE 24,9:PRINT "                                ";
2380 LOCATE 23,3:PRINT "Job":LOCATE 24,2:PRINT "Alloc";
2382 DRAW"c1bm61,183r58h4d8e4"
2384 LINE(120,170)-(180,195),2,BF
2386 LOCATE 20,15:PRINT "Candidate evaluation"
2388 LOCATE 21,16:PRINT "established by (paes)":GOSUB 50
2390 LOCATE 20,15:PRINT "                    "
2392 LOCATE 21,16:PRINT "                    "
2394 LOCATE 23,18:PRINT "C-E":LOCATE 24,18:PRINT "Docs";
2396 DRAW"c1bm181,183r68h4d8e4"
2398 LINE(250,170)-(310,195),2,BF
2400 LOCATE 18,17:PRINT "Performance management"
2402 LOCATE 19,18:PRINT "criteria established":GOSUB 50
2404 LOCATE 18,17:PRINT "                      "
2406 LOCATE 19,18:PRINT "                      "
2408 LOCATE 23,34:PRINT "P-M":LOCATE 24,34:PRINT "Docs";
2410 DRAW"c1bm280,169u13r1d13l2u13g4r8h4"
2412 LINE(250,130)-(310,155),2,BF
2414 LOCATE 18,12:PRINT "(paes) searches for"
2416 LOCATE 19,13:PRINT "best qualif cands":GOSUB 50
2418 LOCATE 18,12:PRINT "                   "
2420 LOCATE 19,13:PRINT "                   "
2422 LOCATE 18,34:PRINT "Cand":LOCATE 19,33:PRINT "Search"
2424 DRAW"c1bm280,129u13r1d13l2u13g4r8h4"
2426 LINE(250,90)-(310,115),2,BF
2428 LOCATE 13,15:PRINT "BQ list provided"
2430 LOCATE 14,16:PRINT "to supervisor":GOSUB 50
2432 LOCATE 13,15:PRINT "                "
2434 LOCATE 14,16:PRINT "                "
2436 LOCATE 13,35:PRINT "BQ":LOCATE 14,34:PRINT "List"
2438 DRAW"c1bm280,89u13r1d13l2u13g4r8h4"
2440 LINE(250,50)-(310,75),2,BF
2442 LOCATE 9,12:PRINT "Supervisor selects":GOSUB 50
2444 LOCATE 9,12:PRINT "                   "
2446 LOCATE 8,34:PRINT "Supv":LOCATE 9,33:PRINT "Select"
2448 DRAW"c1bm280,49u13r1d13l2u13g4r8h4"
2450 LINE(250,10)-(310,35),2,BF
2452 LOCATE 3,10:PRINT "Notifications made and"
2454 LOCATE 4,10:PRINT "actions done by (paes)":GOSUB 50
2456 LOCATE 3,10:PRINT "                      "
2458 LOCATE 4,10:PRINT "                      "
2460 LOCATE 3,33:PRINT "Action":LOCATE 4,33:PRINT "Taken"
2462 GOSUB 50
2500 '------- hypotheses --------
2502 CLEAR:SCREEN 1:WIDTH 40:CLS:COLOR 14,0
2504 LOCATE 2,10:PRINT "H Y P O T H E S E S":GOSUB 50:IF BKUP$="B" OR BKUP$="S"
THEN 2522
2506 LOCATE 7,5:PRINT "1. E/S Technology can be applied"
```

```
2508 LOCATE 8,8:PRINT "to Personnel Administration":GOSUB 50
2510 DIM AR#(671)
2512 GET(75,30)-(235,160),AR#
2514 VIEW (75,30)-(235,160),1:'viewport for info about #1
2516 LOCATE 5,17:PRINT "       "
2518 LOCATE 6,17:PRINT " BASIS "
2520 LOCATE 7,17:PRINT "       ":GOSUB 50
2522 LOCATE 9,13:PRINT "P-A is Knowledge"
2524 LOCATE 10,13:PRINT "   intensive    ":GOSUB 50
2526 LOCATE 12,13:PRINT " -E/S directly  "
2528 LOCATE 13,13:PRINT "   apply        ":GOSUB 50
2530 LOCATE 15,13:PRINT "P-A is 'Rules'  "
2532 LOCATE 16,13:PRINT "  oriented      ":GOSUB 50
2534 LOCATE 18,13:PRINT " -E/S well suited":GOSUB 50
2536 CLS:VIEW:'close viewport.
2538 PUT(75,30),AR#:GOSUB 50:'restore screen
2540 LOCATE 10,5:PRINT "2. If applied, dollars can be"
2542 LOCATE 11,8:PRINT "saved by reducing personnel":GOSUB 50
2544 GET(75,30)-(235,160),AR#
2546 VIEW (75,30)-(235,160),1
2548 LOCATE 5,17:PRINT "       "
2550 LOCATE 6,17:PRINT " BASIS "
2552 LOCATE 7,17:PRINT "       ":GOSUB 50
2554 LOCATE 9,12:PRINT "Supervisors use  "
2556 LOCATE 10,12:PRINT " E/S directly    ":GOSUB 50
2558 LOCATE 12,12:PRINT "E/S automatically"
2560 LOCATE 13,12:PRINT " accomplish work ":GOSUB 50
2562 LOCATE 15,12:PRINT "Reduced number   "
2564 LOCATE 16,12:PRINT " of personnelists":GOSUB 50
2566 CLS:VIEW(75,30)-(235,160),1
2568 LOCATE 5,15:PRINT "          "
2570 LOCATE 6,15:PRINT " HOW MUCH? "
2572 LOCATE 7,15:PRINT "          ":GOSUB 50
2574 LOCATE 9,13:PRINT "  Currently   "
2576 LOCATE 10,13:PRINT " ----------- "
2578 LOCATE 11,13:PRINT " 6200 People  ":GOSUB 50
2580 LOCATE 12,13:PRINT "              "
2582 LOCATE 13,13:PRINT " $157,000,000 ":GOSUB 50
2584 LOCATE 15,13:PRINT "   Possibly   "
2586 LOCATE 16,13:PRINT " ----------- "
2588 LOCATE 17,13:PRINT " 4500 People  ":GOSUB 50
2590 LOCATE 18,13:PRINT "              "
2592 LOCATE 19,13:PRINT " $109,000,000 ":GOSUB 50
2594 CLS:VIEW
2596 PUT(75,30),AR#:GOSUB 50
2598 LOCATE 15,5:PRINT "3. If implemented, responsibility"
2600 LOCATE 14,8:PRINT "for PA will be fixed with supvs":GOSUB 50
2602 GET(75,30)-(235,160),AR#
2604 VIEW(75,30)-(235,160),1
2606 LOCATE 5,17:PRINT "       "
2608 LOCATE 6,17:PRINT " BASIS "
2610 LOCATE 7,17:PRINT "       ":GOSUB 50
2612 LOCATE 9,12:PRINT "Supervisor input "
2614 LOCATE 10,12:PRINT " controls E/S    ":GOSUB 50
2616 LOCATE 12,12:PRINT "Elaborate safe-  "
```

```
2618 LOCATE 13,12:PRINT " guards are not  "
2620 LOCATE 14,12:PRINT " efficient       ":GOSUB 50
2622 LOCATE 16,12:PRINT "Cost savings     "
2624 LOCATE 17,12:PRINT " are essential   ":GOSUB 50
2626 CLS:VIEW
2628 PUT(75,30),AR#:GOSUB 50
2630 LOCATE 16,5:PRINT "4. Improved consistency of PA will"
2632 LOCATE 17,8:PRINT "be realized":GOSUB 50
2634 GET(75,30)-(235,160),AR#
2636 VIEW(75,30)-(235,160),1
2638 LOCATE 5,17:PRINT "       "
2640 LOCATE 6,17:PRINT " BASIS "
2642 LOCATE 7,17:PRINT "       ":GOSUB 50
2644 LOCATE 9,12:PRINT "System operates  "
2646 LOCATE 10,12:PRINT " same everywhere ":GOSUB 50
2648 CLS:VIEW
2650 PUT(75,30),AR#:GOSUB 50
2652 LOCATE 19,5:PRINT "5. Timeliness of service will be"
2654 LOCATE 20,8:PRINT "orders of magnitude better":GOSUB 50
2656 GET(75,30)-(235,160),AR#
2658 VIEW(75,30)-(235,160),1
2660 LOCATE 5,17:PRINT "       "
2662 LOCATE 6,17:PRINT " BASIS "
2664 LOCATE 7,17:PRINT "       ":GOSUB 50
2666 LOCATE 9,12:PRINT "Computers faster"
2668 LOCATE 10,12:PRINT " than people    ":GOSUB 50
2670 LOCATE 12,12:PRINT "System available"
2672 LOCATE 13,12:PRINT " at work site   ":GOSUB 50
2674 CLS:VIEW
2676 PUT(75,30),AR#:GOSUB 50
2700 '--------- expert system demo module----------
2702 CLEAR:SCREEN 1:WIDTH 40:CLS:COLOR 14,0
2704 LOCATE 3,13:PRINT "EXPERT SYSTEM":LOCATE 4,10:PRINT "DEMONSTRATION
MODULE":GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 2500
2706 LOCATE 7,11:PRINT "JOB CLASSIFICATION"
2708 FOR Q%=1 TO 4:FOR ZZ%=1 TO 8:CIRCLE (60,50),ZZ%,1:NEXT:FOR ZZ%=1 TO
8:CIRCLE (60,50),ZZ%,2:NEXT:NEXT
2710 LOCATE 7,7:PRINT "=)":GOSUB 50
2712 LOCATE 10,11:PRINT "MIMICS OPM SYSTEM"
2714 FOR Q%=1 TO 4:FOR ZZ%=1 TO 8:CIRCLE (60,74),ZZ%,1:NEXT:FOR ZZ%=1 TO
8:CIRCLE (60,74),ZZ%,2:NEXT:NEXT
2716 LOCATE 10,7:PRINT "=)":GOSUB 50
2718 LOCATE 13,11:PRINT "EXPERT EASE TOOL USED"
2720 FOR Q%=1 TO 4:FOR ZZ%=1 TO 8:CIRCLE (60,98),ZZ%,1:NEXT:FOR ZZ%=1 TO
8:CIRCLE (60,98),ZZ%,2:NEXT:NEXT
2722 LOCATE 13,7:PRINT "=)":GOSUB 50
2724 LOCATE 16,11:PRINT "GS TOO COMPLEX FOR TOOL"
2726 FOR Q%=1 TO 4:FOR ZZ%=1 TO 8:CIRCLE (60,123),ZZ%,1:NEXT:FOR ZZ%=1 TO
8:CIRCLE (60,123),ZZ%,2:NEXT:NEXT
2728 LOCATE 16,7:PRINT "=)":GOSUB 50
2730 LOCATE 19,11:PRINT "WAGE GRADE SYSTEM USED"
2732 FOR Q%=1 TO 4:FOR ZZ%=1 TO 8:CIRCLE (60,147),ZZ%,1:NEXT:FOR ZZ%=1 TO
8:CIRCLE (60,147),ZZ%,2:NEXT:NEXT
2734 LOCATE 19,7:PRINT "=)":GOSUB 50
2736 ' ---------- how it works ------------
```

```
2738 SCREEN 0:CLEAR
2740 SCREEN 1:WIDTH 40:CLS
2742 LOCATE 3,14:PRINT "HOW IT WORKS":GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN
2700
2744 '------ draw computer ---------
2746 A$="M+1,-3M+1,-3M+2,-2M+3,-1"
2748 B$="M+3,+1M+2,+2M+1,+3M+1,+3"
2750 C$="M-1,+3M-2,+2M-3,+1M-3,+1"
2752 D$="M-3,-1M-3,-1M-2,-2M-1,-3"
2754 DRAW "c28BM0,90U50XA$;R80XB$;D50XC$;L75XD$;
2756 DRAW "BM10,80U30XA$;R60XB$;D30XC$;L55XD$;"
2758 DRAW "BM0,100R95D30L95U30"
2760 '------ keys on keyboard -------
2762 FOR Q%=110 TO 125 STEP 5
2764 FOR Z%=10 TO 80 STEP
5:PSET(Z%,Q%):PSET(Z%+1,Q%):PSET(Z%,Q%+1):PSET(Z%+1,Q%+1):NEXT
2766 NEXT
2768 FOR Z%=25 TO 65 STEP 5:PSET(Z%,126),0:PSET(Z%+1,126),0:NEXT
2770 DRAW "C3BM25,125R41D3L41U3":'---- space bar ------
2772 FOR Z=1 TO 500:NEXT
2774 LOCATE 8,19:PRINT "COMPUTER PROMPTS USER"
2776 FOR Z=1 TO 1500:NEXT
2778 '------ data on computer --------
2780 FOR Q%=55 TO 70 STEP 4
2782 FOR Z%=20 TO 60 STEP 4:PSET(Z%,Q%):FOR Z=1 TO 50:NEXT:NEXT:NEXT
2783 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 2700
2784 LOCATE 10,19:PRINT "USER RESPONDS":FOR Z=1 TO 1500:NEXT
2786 '------ blink keyboard ------
2788 Q%=115:FOR Z%=30 TO 70 STEP
10:PSET(Z%,Q%),0:PSET(Z%+1,Q%),0:PSET(Z%,Q%+1),0:PSET(Z%+1,Q%+1),0:FOR Z=1 TO
500:NEXT
2790 PSET(Z%,Q%):PSET(Z%+1,Q%):PSET(Z%,Q%+1):PSET(Z%+1,Q%+1):NEXT
2792 '------ data on keyboard again ------
2794 FOR Q%=55 TO 70 STEP 4
2796 FOR Z%=20 TO 60 STEP 4:PSET(Z%,Q%),0:NEXT:NEXT
2798 FOR X=1 TO 3
2800    FOR Q%=55 TO 70 STEP 4
2802    FOR Z%=20 TO 60 STEP 4:PSET(Z%,Q%):FOR Z=1 TO 50:NEXT Z:NEXT Z%:NEXT Q%
2804    FOR Q%=55 TO 70 STEP 4
2806    FOR Z%=20 TO 60 STEP 4:PSET(Z%,Q%),0:NEXT Z%:NEXT Q%
2808 LOCATE 12,19:PRINT "ET CETERA"
2810 NEXT X
2812 LOCATE 14,19:PRINT "COMPUTER CLASSIFIES"
2814 LOCATE 15,19:PRINT "JOB":FOR Z=1 TO 1000:NEXT
2816 LOCATE 7,4:PRINT "M.V.O.":LOCATE 9,5:PRINT "WG-5":GOSUB 50
2818 LOCATE 19,8:PRINT "BASED ON OPM STANDARDS":GOSUB 50
2820 LOCATE 21,8:PRINT "USES EXPERT JUDGEMENT":GOSUB 50
2822 '-------- module structure defined ---------------
2824 CLEAR:SCREEN 1:WIDTH 80:CLS
2826 LOCATE 2,6:PRINT "E X P E R T   S Y S T E M   D E M O N S T R A T I O N   M
O D U L E"
2828 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 2736
2830 '------ grow square in middle of screen ------
2832 X1%=250:Y1%=100:X2%=320:Y2%=101:FOR Z%=1 TO 15:LINE(X1%,Y1%)-
(X2%,Y2%),,B:LINE(X1%-1,Y1%-1)-(X2%+1,Y2%+1),,B:LINE(X1%,Y1%)-
```

```
(X2%,Y2%),0,B:X1%=X1%-1:Y1%=Y1%-1:X2%=X2%+1:Y2%=Y2%+1:NEXT
2834 LOCATE 12,33:PRINT "W A G E"
2836 LOCATE 13,32:PRINT "G R A D E"
2838 DIM AR%(800):GET (235,85)-(337,116),AR%
2840 GOSUB 50
2842 '------ move square to left edge ------
2844 FOR ZZ%=235 TO 10 STEP -2:PUT (ZZ%,85),AR%,PSET:NEXT
2846 LOCATE 14,4:PRINT "s t a r t"
2848 GOSUB 50
2850 LINE(200,40)-(300,70),,B
2852 LOCATE 7,28:PRINT "A U T O":LOCATE 8,27:PRINT "R E P A I R":GOSUB 50
2854 LINE(200,130)-(300,160),,B
2856 LOCATE 18,28:PRINT "F O O D":LOCATE 19,28:PRINT "P R E P":GOSUB 50
2858 DRAW "BM112,100R45U45R40H5F5G5":GOSUB 50
2860 DRAW "BM157,100D45R40H5F5G5":GOSUB 50
2862 GET (260,0)-(600,20),AR%:'-part of title
2864 FOR ZZ%=0 TO 15:PUT (260,ZZ%),AR%,PSET:NEXT:'-move part title down
2866 FOR ZZ%=260 TO 0 STEP -5:PUT (ZZ%,15),AR%,PSET:NEXT:'-now move it left
2868 GET (0,5)-(320,30),AR%:'-whole title
2870 FOR ZZ%=8 TO 0 STEP -1:PUT (0,ZZ%),AR%,PSET:NEXT:'-now move it up
2872 LINE(400,13)-(500,33),,B
2874 LOCATE 3,52:PRINT "M O B I L E":LOCATE 4,53:PRINT "E Q  S V C":GOSUB 50
2876 LINE(400,38)-(500,58),,B
2878 LOCATE 6,54:PRINT "A U T O":LOCATE 7,55:PRINT "M E C H":GOSUB 50
2880 LINE(300,50)-(398,20)
2882 DRAW "H5D1F5G5D1E5"
2884 FOR ZZ%=1 TO 1000:NEXT
2886 LINE(300,60)-(398,45)
2888 DRAW "H5D1F5G5D1E5":GOSUB 50
2890 LINE(400,180)-(500,199),,B
2892 LOCATE 24,54:PRINT "C O O K";:GOSUB 50
2894 LINE(400,155)-(500,175),,B
2896 LOCATE 21,52:PRINT "F D  S V C":GOSUB 50
2898 LINE(300,150)-(398,188):DRAW "H5R1F5G5D1E5"
2900 FOR ZZ%=1 TO 1000:NEXT
2902 LINE(300,140)-(398,165):DRAW "H5R1F5G5D1E5":GOSUB 50
2904 LOCATE 9,64:PRINT "O p e r a t o r s"
2906 LINE(400,70)-(500,90),,B:LINE(520,85)-(620,105),,B:LINE(520,110)-
(620,130),,B:GOSUB 50
2908 LOCATE 10,52:PRINT "M O T O R":LOCATE 11,52:PRINT "V E H I C L":FOR ZZ%=1
TO 1000:NEXT
2910 LOCATE 12,68:PRINT "F O R K":LOCATE 13,68:PRINT "L I F T":FOR ZZ%=1 TO
1000:NEXT
2912 LOCATE 15,68:PRINT "C R A N E":GOSUB 50
2914 LINE(158,80)-(398,80):DRAW "H5D1F5G5U1E5":FOR ZZ%=1 TO 1000:NEXT
2916 LINE(158,97)-(518,97):DRAW "H5D1F5G5U1E5":FOR ZZ%=1 TO 1000:NEXT
2918 LINE(158,115)-(518,115):DRAW "H5D1F5G5U1E5":FOR ZZ%=1 TO 1000:NEXT:GOSUB 50
2920 LINE(400,125)-(500,145),,B:LOCATE 17,56:PRINT "A / C":LOCATE 18,55:PRINT "M
E C H":GOSUB 50
2922 LINE(158,125)-(398,125):DRAW "H5D1F5G5U1E5":GOSUB 50
3000 '---------------- critical issues -----------------
3002 CLEAR:SCREEN 1:WIDTH 40:CLS:COLOR 1,1
3004 LOCATE 2,12:PRINT "CRITICAL ISSUES"
3005 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 2822
3006 LOCATE 7,8:PRINT "MIMIC CURRENT SYSTEM?"
```

```
3008 LOCATE 8,8:PRINT "SYSTEM CHEATERS"
3010 LOCATE 9,8:PRINT "IMPERSONAL PERSONNEL"
3012 LOCATE 10,8:PRINT "COSTS TO IMPLEMENT"
3014 LOCATE 11,8:PRINT "IMPACT ON CAREERISTS"
3016 LOCATE 12,8:PRINT "HOW TO DEVELOP":GOSUB 50
3018 '--------store each issue---------
3020 DIM AR1#(50):GET(55,47)-(222,55),AR1#
3022 DIM AR2#(50):GET(55,55)-(222,63),AR2#
3024 DIM AR3#(50):GET(55,63)-(222,71),AR3#
3026 DIM AR4#(50):GET(55,71)-(222,79),AR4#
3028 DIM AR5#(50):GET(55,79)-(222,87),AR5#
3030 DIM AR6#(50):GET(55,87)-(222,95),AR6#
3032 '----store issues in pouch------
3034 DIM AR#(270):GET(49,47)-(221,95),AR#
3036 FOR ZZ%=35 TO 110:PSET(227,ZZ%):FOR XX%=1 TO 25:NEXT:NEXT
3038 DRAW"BM227,35F5D65GS"
3040 PAINT (229,55),2,3
3042 FOR ZZ%=55 TO 225 STEP 7
3044 PUT(ZZ%,47),AR#,PSET
3046 GET(ZZ%,47)-(223,95),AR#
3048 NEXT
3050 FOR ZZ%=5 TO 15:LOCATE ZZ%,25:PRINT "                ":NEXT
3052 GOSUB 50
3054 '----bring them back one at a time------
3056 FOR ZZ%=190 TO 50 STEP-2:PUT(55,ZZ%),AR1#,PSET:NEXT
3058 FOR ZZ%=199 TO 59 STEP-2:LINE(55,ZZ%)-(222,ZZ%),0:NEXT:GOSUB 50
3060 FOR ZZ%=190 TO 75 STEP-2:PUT(55,ZZ%),AR2#,PSET:NEXT
3062 FOR ZZ%=199 TO 84 STEP-2:LINE(55,ZZ%)-(222,ZZ%),0:NEXT:GOSUB 50
3064 FOR ZZ%=190 TO 100 STEP-2:PUT(55,ZZ%),AR3#,PSET:NEXT
3066 FOR ZZ%=199 TO 109 STEP-2:LINE(55,ZZ%)-(222,ZZ%),0:NEXT:GOSUB 50
3068 FOR ZZ%=190 TO 125 STEP-2:PUT(55,ZZ%),AR4#,PSET:NEXT
3070 FOR ZZ%=199 TO 134 STEP-2:LINE(55,ZZ%)-(222,ZZ%),0:NEXT:GOSUB 50
3072 FOR ZZ%=190 TO 150 STEP-2:PUT(55,ZZ%),AR5#,PSET:NEXT
3074 FOR ZZ%=199 TO 159 STEP-2:LINE(55,ZZ%)-(222,ZZ%),0:NEXT:GOSUB 50
3076 FOR ZZ%=190 TO 175 STEP-2:PUT(55,ZZ%),AR6#,PSET:NEXT
3078 FOR ZZ%=199 TO 184 STEP-2:LINE(55,ZZ%)-(222,ZZ%),0:NEXT
3080 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 3000
3100 '------ have a good day ------
3105 CLEAR:SCREEN 1:WIDTH 40:CLS
3107 LOCATE 3,5:PRINT "HAVE":LOCATE 5,7:PRINT "A"
3110 FOR Z%=95 TO 99
3115 CIRCLE (160,100),Z%
3120 NEXT
3130 FOR Z%=1 TO 15
3135 CIRCLE (130,75),Z%
3140 NEXT
3145 FOR Z%=1 TO 15
3150 CIRCLE (190,75),Z%
3155 NEXT
3160 FOR Z%=96 TO 100
3165 CIRCLE (160,Z%),70,,3.5,6
3170 NEXT
3175 LOCATE 21,34:PRINT "GOOD":LOCATE 23,34:PRINT "DAY"
3200 PAINT (160,100),2,3
3205 GOSUB 50:IF BKUP$="B" OR BKUP$="b" THEN 3000
```

```
4000 IF BKUP$="Z" OR BKUP$="z" THEN RUN "BUMBLBEE"
4002 GOTO 3900
chained program for map

100 '------- geographic locations of cpos ---------
105 SCREEN 2:WIDTH 80:KEY OFF:CLS:CLOSE:DEFINT A-Z
110 DEF SEG=&HB800:BLOAD"usa.dat",0
115 LOCATE 2,30:PRINT"Army CPO's in CONUS"
120 '--- blink the dots ----
125 FOR ZZ%=1 TO 2
130 FOR PQS=1 TO 92
135 READ X1,Y1
140 PSET(X1,Y1),1: PSET (X1+1,Y1+1),1: PSET(X1+1,Y1),1:PSET(X1,Y1+1),1
145 NEXT
150 RESTORE
155 FOR PQS=1 TO 92
160 READ X1,Y1
165 PSET(X1,Y1),0: PSET (X1+1,Y1+1),0: PSET(X1+1,Y1),0:PSET(X1,Y1+1),0
170 NEXT
175 RESTORE
180 NEXT ZZ%
182 DATA 480,105,550,52,400,105,440,40,375,65,490,75,80,20,510,75,435,90
184 DATA 130,70,300,140,518,58,320,95,535,40,538,82,340,72,550,53,375,120
186 DATA 560,43,500,103,402,57,300,80,390,110,22,85,208,77,485,105,32,92
188 DATA 435,80,475,96,30,70,213,80,500,55,330,100,510,85,345,85,50,80
190 DATA 545,46,140,70,340,110,510,95,15,75,440,42,570,40,395,128,500,60
192 DATA 80,27,530,70,495,55,415,92,430,100,370,80,145,112,360,105,50,25
194 DATA 525,78,300,100,535,88,490,110,215,82,100,108,365,100,430,115
196 DATA 445,75,382,60,315,78,580,41,465,80,340,42,551,56,510,45,520,72
198 DATA 525,58,495,84,402,60,427,72,538,38,300,120,535,55,425,63,415,82
200 DATA 24,90,440,110,530,43,435,120,40,65,552,58,520,44,15,78,520,53
202 DATA 340,125,290,110,230,130
215 LOCATE 18,5:PRINT "133 Operating CPO's"
220 IF INKEY$="" THEN 220
225 LOCATE 20,5:PRINT "plus 43 Overseas"
230 IF INKEY$="" THEN 230
232 LOCATE 22,5:PRINT "plus 40 Staff CPO's"
233 IF INKEY$="" THEN 233
235 LINE (250,165)-(370,177),,B
236 LOCATE 22,35:PRINT "216 Total"
249 IF INKEY$="" THEN 249
250 CHAIN "BRIEF513",2000,DELETE 100-250
```

APPENDIX G

SEVERIN JOHNSON'S REPORT

My detail to assist Mr. Loren Martindale began on 1 April 1985 and initially consisted of telephoning CPO's in Army and later in contacting those that had been identified as "experts" in classification. When this portion off the assignment was nearing completion I asked and Loren agreed that I could tackle the development of a classification "expert system". My familiarity with any type of computer system was limited to the information needed to classify ADP jobs and a couple of hours running a tutorial on an IBM PC the day I was told I would be detailed to assist Loren, 29 March 1985. My personal experience included about ten years as a classifier, three years as a generalist (R&P,MER,PM&C), and two years as a CPO. So it appeared to Loren and I that this may be a good test of whether it would be possible for reasonably intelligent personnelists to develop the skills to automate their own functions.

The approach taken was for Loren to provide me an hour or so of hands on instruction with the "Expert Ease" software and the IBM PC hardware I had access to at Oakland Army Base. I then set about reading the narrative material of the software to better understand what the software was capable of. The first standard I chose to develop an expert system on was the Evaluation Guide for Typists. The only problem I encountered was an inability to make the software do what it promised because I was applying typewriter logic to the keyboard. Once I understood better the functioning of the keys all went quite well and the system was developed in about two days. It was tested later and appears to be usable by operating officials.

With my appetite whetted with that experience I felt ready to tackle something with a little more complexity. The second standard I chose was the Supervisory Grade Evaluation Guide. I felt I knew that standard as well as any and it had more broad based usage potential than some of the more numerous transportation family jobs that I was most familiar with at Oakland Army Base.

Over the course of the next three weeks I spent a number of hours on the computer and at my desk working out a logic that would allow for the automation of that standard. The process with the software was not difficult and I felt that the results were quite complete even though my ADP skills have remained quite rudimentary.

The process left me with several impressions and led me to several conclusions. The automation of classification standards does not require an expert in the standard, however it does seem to require someone who has a strong background in classification principles and policies. I would venture to say that a well

grounded classifier could take any classification standard and automate it. The staffing process could be used to refine the automation and build in occupation unique experience from classifiers who have had extensive field experiences in the occupation. Possibly even from those that have been identified as experts in this project.

The use of expert systems if not used totally by supervisors and managers has a good chance for success as a training tool for interns, as a tool to help classifiers explain classification to supervisors and employees and finally as a tool to speed up the classification process. Interns could more quickly develop an understanding of a classification standard by being able to rapidly see how different sets of data interact in order to classify a position. Access to the building blocks of an expert system could also help to better understand the logic upon which the standard is established. The explanation of classification could be enhanced by the classifier taking a supervisor through the automated standard and thereby being able to point out areas of specific disagreement and faster dialogue on what caused the selection of different values for a factor in disagreement. Desk audits are not the most efficient means of gathering data. An expert system could help the classifier better focus on the essential data necessary for classification and eliminate or reduce the gathering of extraneous data.

I also tested the developed SGEG system on a variety of supervisory positions. The test was run with second and third line supervisors and as can be seen by the following chart there was a good mix of Part I and Part II jobs.

Standard	Current Class	Expert Class	Differences
Part I	GS-2003-09	GS-2003-8	GS-9 based on non-supv d.
Part II	GM-802-13	GM-802-14	Ovrstd Mgr. Aspects
Part I	GS-332-12	GS-332-12	
Part I	GS-503-09	GS-503-08	Misclassification ?
Part II	GS-2130-11	GS-2130-11	
Part II	GS-2130-12	GS-2130-12	
Part II	GS-510-11	no class	Based on non-supv duties
Part II	GM-334-13	GM-334-13	

The average time to classify these positions was twenty minutes. Although the second time through the same part for a different job cut down the time almost in half.

The biggest problem in the test was that the language was more classifier friendly than supervisor friendly. A lot of the development time would therefore have to be spent in formulating questions that are supervisor friendly. The classification standards are now written for classifiers and need substantial adaptation in order to be consistently understood by supervisors. For instance a recurring problem surrounded the definition of "manager". For many of the supervisors a "manager" was no different than a supervisor. Some of these limitations may have been ironed out in the final version of the program which added

more words of clarification and explanation.

Finally, the extreme number of factors in the SGEG, especially Part I proved to be more than the "Expert Ease" software was capable of handling. Therefore the final version of Part I should accurately classify most supervisory jobs but the physical limitations of this software will cause some jobs to be misclassified. More powerful software or a different logic approach should overcome that limitation. The nature of Part II was such that there were no such size limitations and Part II should more consistently provide correct classifications as it currently stands. I will add that there may be some classifiers that would argue some of the logic employed in the standard as it currently stands. I am not saying it is perfect in every way!

The three weeks development time appears to be a reasonable length of time given the limited system expertise I had when starting the project. Today a similar standard would take less development time.

Although no attempt was made, it is reasonably clear that the expert system concept could easily be used in areas other than PM&C. X-118 determinations could easily be made. Crediting plans could be easily automated. There are many uses in Technical Services especially when advising employees on retirement options, etc. In MER disciplinary actions are ripe for the use of expert systems. In summary any personnel function that can be explained to someone else can be put on an expert system. Hopefully, that should mean all areas of the personnel office. Incidentally it is feasible for individual personnel offices to start using expert systems technology right now. The software in available, the skills are easily learned, and the personnel expertise resides in all personnel offices to one extent or another.

APPENDIX I

CRITICAL ISSUES QUESTIONNAIRE

The following questionnaire questions have been posed to approximately 70 professional personnelists. Responses were received from six, and their comments summarized. The final pages of this appendix includes the reports from three work groups who discussed the ideas presented at a professional development seminar held in the Pentagon on 2 May 1985.

MIMIC CURRENT SYSTEM?

To what degree do you believe an expert system should mimic our current system with respect to policies, rules and regulations?

Exactly/totally. The system must produce results, advice, decisions and actions that are identical to those that are produced by personnel people, doing their jobs correctly, under our current system.

God forbid! The current system is pretty s.... and there's no reason to emulate that.

Close resemblance. The system must closely follow general policies, rules and regs, but some of the specific minute details which do not contradict these policies could be handled in any way most amenable to efficient operation of the system. [EXAMPLES: We currently utilize large numbers of forms for record purposes. As long as information is available, is it crucial that these forms continue to be the only accepted documents? We currently have the capacity to respond to ANY question posed from staff levels above us, frequently devoting much time and effort to research to generate non-recurring, special purpose information. Is it crucial that this ability to ask for never-done-before responses from operating CPO's be preserved?]

Checked 4 times.

I believe the Federal personnel system needs a well-defined structure that provides uniformity in the way employees are treated. Without it, we would have a horrendous problem with credibility. As it is, there is certainly enough discretion and flexibility, not to mention latitude in interpretation, in the current system to create a certain amount of incredibility in the minds of employees. For example, noncompetitive actions such as reassignment, or reinstatement to a grade no higher than last held, are widely regarded as violations of the merit principle. Differences in the application of the highest previous rate rule, a discretionary matter, also causes consternation. I think people expect uniformity and anything looser than what we now have could be chaotic.

Somewhere between this one and the next one. Ultimately the

system could mimic everything we desire. At first, however, it should mimic the easy stuff from a regulatory base.

Close resemblance would be adequate in my judgment. Anything more radical would be difficult to get approved, i.e. the Civil Service Reform couldn't change the rule of three.

Loose resemblance. The system can be designed to follow general principles, but changes to current regulations and rules could be incorporated as the system is built. [EXAMPLES: The merit promotion principle must be maintained, as well as the principle of equal pay for equal work. However, is it crucial that all current regulatory guidance governing the merit principle be mimiced by the system? Is it crucial that jobs be classified in strict accordance with currently published OPM standards?]

Checked 2 times.

Although a functional analysis of personnel Mgt might conclude that a total revamp is appropriate, obtaining the necessary waivers and approvals might cause the expert system to get stuck in the bureaucracy and we'd never get it implemented. We don't need a 100% mimic; perhaps meet the "intent" rather than the letter of the regulations.

Total revamp. The system can be designed to create an entirely new personnel administration and management environment in which even basic principles are changed. [EXAMPLES: The principle of equal pay for equal work could be replaced with a seniority system, or something even more radically different such as management discretion. The principle of competition for initial competitive appointments by certification from OPM could be replaced by new rules not requiring referrals from OPM.]

Not checked at all.

SYSTEM CHEATERS

How important is it that a system provide continuous oversight to personnel administration and management as it is being performed by managers and supervisors?

Absolutely essential. Any expert system must also provide a means to prevent any deliberate or errorful activities on the part of supervisors, managers and employees. [EXAMPLE: As the system classifies a job based on supervisor input, it simultaneously checks for overlap of functions, good position management principles, etc., and prevents the supervisor from cheating. Additionally, as an employee performs his/her job, reports of tasks performed are entered by the employee, and inconsistencies with job classification are reported to higher levels, or the system automatically reclassifies the job based on tasks actually performed.]

Checked 4 times.

Sorry, but my general view is that it's human nature to try to beat the system. The reason we have a vast body of statutes and regulations now is that the Federal Civil Service was once a corrupt spoils system. It could be again. Who cares about accountability to an inanimate system?

I think the problem here is how much extra would it cost in terms of resources to provide complete oversight to ensure that no cheaters get by. I think it's important but people can note problems on a "by exception" basis to catch cheating.

I believe oversight is essential not so much because of cheaters but because it takes close attention & effort by experts to provide continuous maintenance to keep an organization healthy & vital.

Yes, unfortunately, still accountability alone is not enough, for one reason we've never really disciplined a cheater. When a supervisor's valid best interests are to cheat then he or she must cheat some just to get the job done.

I'm not comfortable with either extreme. The police role is, I think, incompatible with the operation of an expert system. However, neither can I say the sky's the limit with no checks and balances unless we are also prepared to say that pay accuracy, etc., are no longer objectives of the Federal Personnel management system. I think that's the real question here - what are the objectives of the personnel management system? If the factors you describe above are legitimate objectives, then there must be some controls. If not, then controls are not necessary.

Not important. Supervisors and managers are responsible for personnel management and administration. An attempt to produce an expert system that plays policeman will continue to duck the issue of accountability.

Checked 1 time.

I'm struggling with this question, but I definitely lean to this answer. Build on the changes in manpower "ceilings" (the FY85 test) - and see how far we can get management accountable for $$(something tangible). This approach implies that classification may have to be developed at a later stage (when the manpower issues straighten out) but the emphasis on supv assigning duties is critical and should not be mislaid.

IMPERSONAL PERSONNEL

The personnel business would likely become very impersonal from an operational point of view under an expert system. Thus, a personnel office would not exist that would provide ombudsman services. While technical advice would be available on line, personal counseling services in light of this technical advice would have to be performed by supervisors. What are your reactions to this?

Horrified. The personal advisory services provided by personnelists is one of the most important functions we perform. The Army would be making a grave mistake to give up the unmeasurable benefits that result from the many specialists that are available to supervisors and employees in personnel offices. Our beneficial effects on helping to maintain good morale in the workplace by being there must be preserved.

Checked 2 times.

I believe personal advisory service by personnelists is most essential and a great assistance to supervisors.

I'm not horrified, but I don't think the next level is sufficient. Some reduction in CPO staffing may occur. but not 50% or more.

My experience with personnel offices is that they are already impersonal and not particularly professional so no loss here. I think personnelists are responsible for a large amount of poor morale due to their lousy service.

This is not such a loss - how much "personal advisory service" do we do now?

Concerned. While we provide valuable morale enhancing services, these services could be insured by maintaining a small staff of personnelists whose role as management-employee relations generalists would be available to employees and supervisors. While the system may produce the technical nitty-gritty service to supervisors and employees, the role of these generalists would ensure a counseling service as an escape valve for those who cannot get it from their supervisors.

Checked 3 times.

Disagree that they are simply "morale enhancing" services. Even after the expert system, there's a need for management advice and support on a technical level; that is, "how best to assign duties", position management options, options/methods for filling jobs. Where decisions remain, there is need for person to person management assistance.

I agree here. A small professional staff could do a better job if taught to provide service and counseling.

Again, I have a rather cynical view of the ability of supervisors to provide effective personal counseling. They are often too close to the problem or a part of the problem. I believe there will be a need for some personal, personnel contact. Also, there are numerous special programs I believe will defy being built into an expert system that will need personal guidance to maintain them. Examples: Handicapped hiring, rehabilitation of compensation recipients, control of sick leave usage.

That's O.K. Supervisors have the responsibility for this function. Social services should not be a function of the personnel office.

Disagree. "Social services" should be a function of the CPO. Most supervisors don't know or understand the personnel rules and I'd be reluctant to give up personnel expertise altogether.

COSTS TO IMPLEMENT

It is likely that an expert system will cost a considerable sum of money to even get it to the testing phase of operation. Costs will be driven by various factors such as how closely it mimics our current system, what kind of hardware is needed, whether or not software development is done in house or by contractors, how much of our business is included in such a system, etc. How much do you feel the Army should commit to such an undertaking?

Drop the idea now. Our functions cannot, or should not be performed by an expert system in any way.

Checked 1 time.

An expert type system is more feasible in some functions than others such as classification. However, I don't think it is worth the effort. I can see an expert system as a research tool in the legal field, labor relations, etc.

Move very cautiously. Invest no more than maybe $500,000 initially. Do what can be done for this amount, regardless of how limited it might be in terms of what is does. Assess what came out of the effort in terms of what it does, and the promise it holds.

How can you suggest $500,000 and hold without some concise estimate of the cost of getting to a showable product!

Move somewhat boldly. Commit to a test (demonstration) system of considerable scope in terms of the functions it performs (for example classification and staffing) but of limited impact on an installation mission (for example one or two organizational functions at an activity). Place it in an operational setting and examine/evaluate its feasibility/problems/potential. The dollar costs can be whatever they are to do this.

Checked 5 times.

Commit to a test (or demo) system based on hard cost estimate. If necessary, fight for additional funds to get there. Be flexible about what functions to test - class only? staffing only? Start "small scope" so we can study impacts, costs & validity.

If there is a positive outcome of the initial developmental phase, it's a waste of time and money to do less than an

operational test.

I feel this is the preferred move. We should go for this level of support.

This is fairly realistic if you can keep it under $1 million. We should develop a PDIP for this project ASAP.

Move very boldly. Commit to a significant demonstration project either in terms of scope (i.e. the functions to be included) or impact (i.e. a test installation at which all activities are serviced by the system), or both. Cost should be no object.

I'd like to see this happen, but having watched how the Army staff operates it's unlikely.

IMPACT ON CAREERISTS

A fundamental premise of creating an expert system is it will actually save money by replacing personnel. The validity of this premise is currently under investigation, and may not be proven or disproven until an actual demonstration project is undertaken. However, if an expert system is eventually put into operation, it must cost less to provide personnel services utilizing it than would be expended under a system where people do the work, or there is very little reason to do it. How do you feel about the idea of undertaking a project that has as its basic tenant, the goal of replacing occupational opportunities for a group of people?

Against it. It matters not whether it can be done, or whether quality or manner of operation are changed. It is simply undesirable to set out to dismantle an occupational field providing employment to people.

Checked 1 time.

Currently the United States is steadily losing its middle class due to foreign competition & .other reasons which is most undesirable. I oppose this kind of thing as a social policy.

For it. If it can be done, it should be. The people can be retrained. Doing the job at less cost is more important than the impact it might have on the current and future people doing this work.

Checked 5 times.

Some "expertise" will still be required:
a. Maintain the expert system.
b. Provide person to person contact (generalist) when necessary for decision-support.
Also, the issue is not just "less cost" but
1. consistency
2. timeliness

3. That is, better

We'll carve out a role for generalists in doing non-administrative non-clerical things.

My sense is that it will be a very gradual process for supervisors to become adept in using an expert system, and a considerable amount of attrition can take place during the phase-in period. Further, it seems to me that although the personnel staff will be considerably smaller, those who remain will be doing the work that represents the best part of personnel work. The drudgery work will be done by the system.

We should not live in the past, new roles will pop out as essential, human effort will be raised to a higher plane.

Great idea. Personnelists are a high priced group of paper shufflers. It's unlikely we'll ever be rid of them all but maybe this system will contribute to them doing a better job.

HOW TO DEVELOP

If Army undertakes further examination of using expert systems in personnel administration, it would be wise to develop a demonstration (test) of such a system. The manner in which this should be done is being assessed now. If a demonstration project were undertaken, how do you think it should be developed? The following statements are provided to stimulate thoughts in this regard. You need not limit yourself to these statements only. Any suggestions you may have are welcome.

I believe the idea should be dropped at this time. Do not invest any more effort, time or money in the expert system idea.

It is important to proceed very cautiously, perhaps hire a professional expert system development consultant to assess the problem before undertaking any commitment to a demo project.

The demonstration project should be undertaken very soon if it is at all technically feasible.

Set up a special group in D.C. to develop it. Then select an installation at which to test it.

Assign the project to a major command to develop it and test it. Army to fund it.

Army to assign project to an installation directly. Army to fund it.

Keep all software development done in house.

Contract software development.

Any project office must have direct access to decision/policy makers, but it is very important to undertake even the initial

development of such a system at a test site rather than at a staff level.

Please include any other ideas you may have on how we might proceed to develop a demonstration project if one seems to be feasible.

The originator of the idea should continue with the development of a demonstration project and should be given the latitude to select the help he needs as well as the test installation. The reason for this is that there will almost certainly be considerable resistance to this idea among personnelists all the way up to top staff levels.

To have a chance of success, it must be Army sponsored and funded. To put it in DC would likely not put it where best access to technical resources may be located, and runs a high probability of "too many cooks spoil the broth" results. To put it at an installation and under their jurisdiction will likely bump up against too many people who see their way of life threatened. Establish a task force, put them where they have access to necessary technical resources to develop the project, then put it at an installation to test it with oversight and liaison by members of the task force. The task force must have access to and support of decision makers. But it must also have a lot of freedom to do this job.

Continue to develop and test blue collar jobs, classification and demonstrate program at a test site. Depending on resources, expand to low level white collar jobs and other functions.

If you proceed with a test, demonstration project - you should take a small bite of the most feasable area such as classification. I don't think it is very feasable in many functions such as staffing, employee relations.

Very critical:

1. Central funding and leadership
2. Operating-level expertise
3. Ownership: keep it moving

DEPARTMENT OF THE ARMY
U.S. ARMY CIVILIAN PERSONNEL CENTER
200 STOVALL STREET
ALEXANDRIA, VA 22332-0300

REPLY TO
ATTENTION OF
PECC-CID

17 MAY 19[illegible]

MEMORANDUM THRU Chief, HQ Civilian Personnel Office
U. S. Army Materiel Command

FOR Director Civilian Personnel

SUBJECT: Nick Hoge Professional Development Seminar - Group II Discussion Report

1. Mr. Martindale's presentation and essay "A case for Expert Systems in Personnel Administration" set the tone for enthusiastic and thought provoking discussion about the use of automation in the every day business of civilian personnel management. This report covers the primary areas of discussion and recommendations made during the session.

2. General Discussion.

The group viewed the advance of automation in the personnel business including expert system application, to be a positive step forward. Some concern was expressed that as more and more of the personnel functions become automated we run the risk of losing the personal interaction that goes on today. Many of the group participants disagreed stating that automation would reduce the paper log jams and in reality allow more time for the personal interaction desired. The group looked upon automation not as a threat but rather a support tool.

3. Discussion of the "Ideas for Consideration".

a. Is the proposal valid/of value to the civilian personnel community within Army?

The group consensus was a resounding "yes", but a lot of work needs to be done to have it readily accepted within the personnel and serviced communities. This work includes training, organizing, and funding support which are discussed more fully in the specific points that follow.

b. Should the proposal be expanded or contracted?

The proposal should be expanded to the other personnel programs. The recommendation was made to develop applications for selected programs and distribute them among interested CPOs for testing and evaluation. Recognizing that this approach is not as simplistic as it sounds, the group suggested that Army first develop and refine one program for Army-wide use.

PECC-CID
SUBJECT: Nick Hoge Professional Development Seminar - Group II Discussion Report

c. What are the major obstacles to implementing such a proposal?

Major obstacles identified were:

1. Getting the funding;

2. Overcoming perceived lack of commitment and resistance to change;

3. Identifying and maintaining the human expert base.

d. Should such a proposal be implemented? How?

The group opinion was that indeed such a proposal should be implemented using the formal Project Management approach. This approach would provide the level of control, visibility and relative stability needed to support funding and manpower issues.

e. What about the costs of the system? People? Money? Equipment? Time?

The group agreed that these issues couldn't be fully discussed and answered in the session because of the variables that exist. The group recognized that these issues must be carefully considered, researched, and resolved before automated application could be developed. These issues would be addressed in the Mission Elements Needs Statement for the project.

f. What are the impacts on the Civilian Personnel field? Philosophical? Managerial? Accountability?

There are numerous pro and con impacts in introducing expert system concepts to the personnel business. Philosophically, we need to consider how we will retain and maintain the small human expert knowledge base. Once expert systems were in place, the core knowledge base required at each site would be reduced. We would then have to rely on a smaller (elite?) base to maintain the systems and incorporate policy and legislative changes. Also, in the philosophical vein there are certain cultural barriers that must be worn down. There still exists the reluctance to change and the reluctance to trust machines to make judgmental decisions. Which leads to the managerial impacts. Management must be willing and committed to accelerating the automation program for civilian personnel in Army, stepping up training of personnelists and managers and establishing sound plans to do all of that. From the standpoint of accountability - with respect to the PM&C application presented - the group agreed that accountability still rests with the supervisor. This concept must be fostered if such an expert system is to succeed. Along those lines the group discussed whether or not expert systems or automation in general would thwart would be "system cheaters". The group agreed that automation would not. The answer to dealing with "system cheaters" is not automation but rather training and other means to instill ethical management practices.

17 MAY 1985

PECC-CID
SUBJECT: Nick Hoge Professional Development Seminar - Group II Discussion Report

g. How does this system interrelate to other automation initiatives? VIABLE? ACPERS? Office automation? There is a definite interrelationship between expert system application and current and future automation initiatives. That is why the group proposed the formal project management approach to developing expert systems applications. It is imperative Army have a grasp of its automation programs so automation dollars can be more wisely spent.

4. It was a pleasure to be a part of the discussion group and to see personnelists actively interested and so well versed in today's automation issues.

Leslie D. Smoot
Personnel Management Specialist
ACPERS Project Office

DEPARTMENT OF THE ARMY
HEADQUARTERS US ARMY MILITARY DISTRICT OF WASHINGTON
FORT LESLEY J. McNAIR
WASHINGTON, DC 20319-0400

REPLY TO
ATTENTION OF

ANCIV-XTM 8 May 1985

MEMORANDUM FOR DIRECTOR OF CIVILIAN PERSONNEL

SUBJECT: Nick Hoge Award Professional Development Seminar—INFORMATION MEMORANDUM

1. Purpose. To furnish information on Group III's discussion concerning the impact and application of expert system technology on civilian personnel management and administration. The information emanates from the suggested "Ideas for Consideration" handout provided to panel members (enclosure 1). A list of panel members is at enclosure 2.

2. Information.

a. Is the proposal valid/of value to the civilian personnel community within Army? Yes.

(1) Civilian personnel knowledge would be better catalogued and more easily retrievable.

(2) The system could be used to validate standards as it is programmed and used.

(3) The computer interfaces with nearly all programs in today's environment.

(4) Consistency, standardization and speed would be improved.

(5) The advantage of involving the supervisor would minimize classifier/supervisor/managerial problems.

(6) It would give the personnelist more time to do "expert" work.

(7) DA would attain a better informed managerial work force.

b. Should the proposal be expanded or contracted? Expanded.

(1) The DCSPER organization could attain full automation in 10-15 years, i.e. ACPERS, DA Office Technology Project, and Expert Systems.

(2) Consideration should be given to a pilot project with expansion, if proven.

c. What are the major obstacles to implementing such a proposal?

(1) The need for a strong quality control to avoid problems with the currency of the data base is critical. How many safeguards do we need?

(2) Supervisors/Managers/Personnelist would all require PC/Micro equipment.

(3) An intensive training program would be required to assure current and future supervisors/managers/personnelists are trained and disciplined in the use of the system.

(4) Not everyone agrees with the "school of thought," consequently high levels of resistance.

(5) There is a concern that qualification standards are not validated and we would be making bad situations worse.

(6) Some functions are easier to automate than others.

(7) Idea is idealistic...supervisors classifying jobs. Who would control?

(8) There was a concern for classifiers validation; interface with interviews and classification audit; concern for loss of expert base.

(9) The expertise in the ADP community on expert system is not at all that great at this time.

(10) Hardware is presently unavailable; the need for mainframe equipment for massive storage of data is required.

(11) The requirement for the same full-time functional experts to support development of the life cycle for the system (5-10 years) is not realistic.

(12) There is a potential cost and labor management relations barrier against the project, e.g. AMC depots are under Army Industrial funds and have strong unions.

(13) What happens to grade control?

(14) The loss of personal contact with serviced activities.

(15) Presently, not enough resources for ACPERS let alone an expert system.

d. Should such a proposal be implemented? Yes. How?

(1) Establish a plan of action, milestones to include quality control and training, and a formal project officer.

(2) Consider the piece-meal bases, i.e. one function versus all at one time approach.

(3) Use of mainframes, VIABLE sites, DA Office Technology Project, supplemented with additional software, and communication technology, should be considered for on-line system.

(4) Purification of classification standards would be realized as new system is utilized. Would require OPM to be pro-active.

(5) Set-up test sites (pilot study), establish phase plan for classification series; expand based on pilot study; and delegate different series to different installations with a task group control to assure consistency.

(6) Give consideration to China Lake concept (demonstration type project).

e. What about the costs of such a system? People? Money? Equipment? Time?

(1) Cost and resources would be high initially but long range benefit is great.

(2) There would be a long, long, period of education.

(3) Cost of equipment should be coordinated with ISC for planning, budget, software, and hardware, e.g. VIABLE.

(4) Action lends itself to Learning Centers; consideration should be given to the training function being responsible.

f. What are the impacts on the Civilian Personnel field? Philosophical? Managerial? Accountablity?

(1) A new way of doing business would have to be realized.

(2) Would require committment of all concerned.

(3) The variety of socio-economic needs of our work force should be considered.

ANCIV-XTM
SUBJECT: Nick Hoge Award Professional Development Seminar--INFORMATION MEMORANDUM

(4) We should not assume the system will operate in a vaccum; devoid of human intervention.

(5) The expert level of personnel people could realize some degradation.

(6) How many safeguards do we need?

(7) Degree of fear; endangered species; organization change.

g. How does this system interrelate to other automation initiatives? VIABLE? ACPERS? Office automation?

(1) The expert system would be utilized by all DA Civilian Personnel Offices and therefore, would be considered a Standard Army Management Information Systems (STAMIS) and have VIABLE constraints; system should not be maintained by individual CPO's.

(2) DA Office Technology Project would have to be upgraded to support expert systems.

(3) ACPERS is a data base management system and presently, expert systems software does not intergrade.

3. The subject aroused the curiosity and interest of the panel members. The agenda for the seminar seems to be a good approach and should work well in future seminars.

LARRY E. HOLLOWAY
Deputy Civilian Personnel Director

2 Encls
1. Ideas for Consideration Handout
2. List of Attendees

Gladys M. Tulloch/475-1601
Typed by Pamela J. Ransom

DEPARTMENT OF THE ARMY
WALTER REED ARMY MEDICAL CENTER
WASHINGTON, D.C. 20307 -5001

REPLY TO ATTENTION OF

HSHL-CPP

SUBJECT: Group I - Discussion Group Report

THRU: ~~Mrs. Betty D. Allen~~ GA 14 May 85

TO: Mr. Raymond J. Sumser
Director of Army, CPO
PECC-CID Room 3N69
200 Stoval Street
Alexandria, VA 22332-0300

1. The purpose of this report is to provide a feedback - synopsis of the many comments, remarks, and most importantly the enthusiastic discussion generated by Mr. Loren D. Martindale's paper, "The Case For Expert Systems For Personnel Administration."

2. Mr. Martindale's presentation was excellent. It exhibited the viability of the expert system; - a selling tool; an educational tool; a working tool; to assist in solving personnel problems.

He captured everyone's attention during his introductory course analysis remark regarding "Eliminating 4500 personnel specialist out of 6200 careerist," currently in the system. However, later discussion revealed many personnel specialist may switch to other fields within the personnel system and that attrition and "phase in time" would assist in accommodating any reduction in personnel.

3. The major obstacles to implementing such a proposal would be in our opinion:

a. money - upfront - expenses, acquisition, installation, training, and maintenance;

b. training of supervisors in the system approach to personnel management;

c. acceptance by managers - history of past performance with a system approach may pose a creditability problem;

d. lack of personal contact;

e. abuse of the system;

f. who will be accountable for the system;

g. the system will demand a higher level more intense and a broader area of expertise in the personnel function(s) by the personnelist than that which is now possessed by most personnelist;

h. an unknown impact factor: personnel information is a concern of the Information System Command, (ISC), Reference - ISC letter subject: Information Management Master Planning (IMMP) Guidance, dtd 28 March 1985, how will these organizations affect the personnel function?

4. The consensus of the group regarding the implementation of the system is to follow a non-combative role. For example, implement the classification function later and introduce a "helping hand" service approach in the area of employee benefits, it may be introducted by phases:

- Phase I - a. Health Insurance selection from among 120 plans available in the D.C. area - based upon family health, cost, etc;

  b. Life Insurance selection;

  c. Retirement;

  d. Training and Development.

- Phase II - a. Employee Relations

  (1) Local - problems and decisions
  (2) MSPB decisions

  b. Labor Relations

  (1) Local - local problems and decisions
  (2) FLRB decisions.

(NOTE: Several private sector firms have computer assistance case decisions systems in operation).

- Phase III - Recruitment and Placement

(NOTE: FORCOM, Huntsville, Alabama has a system in place and operating).

- Phase IV - Position Classification and Wage Survey - (To include total compensation package).

5. Is Mr. Martindale's proposal valid? Is it of value to the Army Personnel Community?

- The Group I answers to these two questions is that many of us in the personnel field are already moving toward this direction. Perhaps in a non-directional non-centralized approach. For example,

HSHL-CPP
SUBJECT: Group I - Discussion Group Report

Walter Reed Army Medical Center - has completed a computer approach to the nurse occupation, 610 series. The number of nurse position descriptions have been reduced from 95 position descriptions to 23. Reduced the write-up time from 4 to 5 hr to approximately 45 minutes. Mr. Martindale's presentation has sent us back to the 610, 621, and 620 series to refine the program along the lines of Mr. Martindale's proposal. In addition, Walter Reed Army Institute of Research has approved the purchase, installation, and training of personnelist to computerize all WRAIR personnel systems. Many of Mr. Martindale's ideas will be incorporated in this system.

- Group I's opinion is that the proposal is valid and it has great value to the Army Personnel Community. Collectively, the group's opinion, many operating civilian personnel offices are expanding in this area and there should be centralized guidance and expertise available to the CPOs.

6. Implementation. The group recommendations:

a. expand the proposal to do a feasibility study by utilizing a demonstration project;

(1) establish sub-demonstration projects at several different geographic locations,
(2) each sub-demonstration project will work one functional area of personnel or a smaller component of it,
(3) to ensure a conceptual understanding of the application of the entire AI to the total personnel system. All personnel functions should be studied simultaneously.
(4) for control and comparative analysis, demonstration projects should be established where there is:

- considerable collection of expertise, equipment, and application and operating experience with AI within the CPO;
- less than what is discussed in 4 (a) above;
- no expertise, no equipment, and no computer equipment.

b. It is further recommended that Mr. Martindale be placed in the position of an operating manager for the demonstration project.

FREDERICK W. DENECKE
Chief, Pos & Pay Mgmt Division
Civilian Personnel Office

APPENDIX J

CONTACTS PROVIDING INFORMATION/CONSULTATION

Advanced Information & Decision Systems. Mountain View, CA. Mr. Cliff Reid. (415) 941-3912.

Balistics Research Labs. Aberdeen Proving Ground. Mr. Mort Hershburg. AVN 298-6661.

Soldiers Support Center. Ft. Ben Harrison, IN. Maj. Ken Rose. AVN 699-3791.

Office of Naval Research. Arlington, VA. Ms. Susan Chipman. (202) 696-4318.

Arthur Anderson Co. Phoenix, AZ. Mr. Steven Dick. (602) 257-9234.

Teknowledge. Los Angeles, CA. Mr. Allen Smith. (805) 495-8265.

Stanford University. Palo Alto, CA. Mr. John McCarthy, Mr. Tom Rindsleisch, Ms. Sandy Learner, Mr. Gordon Bower.

IntelliCorp. Menlo Park, CA. Mr. Fred Cummins. (415) 853-5593.

Lisp Machine, Inc. Los Angeles, CA. Mr. Kenneth Gruber. (213) 642-1116. Santa Clara, CA. Mr. Warren Goddard. (408) 496-1151.

Scientific Systems, Inc. Cambridge, MA. Mr. Webb Stacy. (617) 661-6364.

Software A&E. Arlington, VA. Mr. Tony Magliero. (703) 276-7910.

Smart Systems Technology. McLean, VA. Mr. Eamon Barrett. (703) 448-8562.

Inference Corporation. Los Angeles and San Francisco, CA. Mr. Pete Larson, Mr. Shelton. (213) 417-7997, (415) 461-0513.

And the many professional personnelists within the Department of Army.

APPENDIX K

SCOPE OF WORK STATEMENT

The contractor will provide to the Department of Army an expert system which will accomplish all of the tasks specified herein. The system will operate in an integrated fashion, mimic the expertise of experts provided by the Army as models, and be free of errors, in both programming, and expert decisions rendered by the system.

GENERAL DESCRIPTION. The system will perform the functions of a position classification specialist in an operating civilian personnel office. It will classify jobs, provide position management advice, make Fair Labor Standards Act determinations, advise on hazard pay and environmental differential pay, determine functional classifications, make determinations of supervisory code, produce job descriptions and evaluation statements, maintain records of its use (responses from its users), and work in a mixed-initiative mode. The system will be directly usable by supervisors and employees of the activity from computer terminals located at several locations throughout the installation.

FOUNDATION OF THE SYSTEM. The system will use as the basis for rules the current Office of Personnel Management, Department of Defense, and Department of Army rules, regulations, manuals, and policies which are in published form. Interpretation of these published rules will be provided by Army to the contractor as required.

EXPERTS. The Department of Army will provide human experts to the contractor for use in the development of the system. Experts will serve as models for various aspects of the system development. Experts will provide to the contractor the knowledge possessed of interpretation of regulations, as well as judgmental knowledge needed for decision processes. Additional experts in the same subject matter area may be provided by DA to test the system, and make adjustments to the decision processes used. All differences in expertise among experts will be resolved by the DA project manager.

SYSTEM PERFORMANCE. Following are the criteria the system must perform.

1. The system will be able to link to and use Army standard data base systems such as ACPERS.

2. The system must contain the ability to properly classify any and all jobs in the organizational entity prescribed.

3. The system must provide this classification service in an interactive query format available to supervisors establishing new jobs, or redefining existing jobs.

4. Classification decisions on positions rendered by the system will be recorded in an organizational file of the activity. This organizational file will contain sufficient information on all positions for use by any other part of the system for operation.

5. The system will maintain an audit trail of the classification decision process it used and store it with the final product in the organizational file.

6. The system will provide security so that only authorized users may utilize it for their own positions.

7. The system will produce a job description similar to current Army practices.

8. The system will produce an evaluation rationale readable by humans that justifies the classification on the basis of criteria contained in OPM classification standards.

9. Position management advice will be readily available to managers that takes into consideration such factors as average grades, supervisory ratios, trends, costs, career ladders, grade controlling duties among all positions, functional responsibilities and similar matters.

10. Decisions about hazard pay and environmental differential pay will be provided by the system.

11. Supervisory codes will be provided by the system.

12. The system will make accurate determinations regarding the Fair Labor Standards Act for all positions within its purview.

13. The system will be capable of handling mixed jobs.

USER INTERFACE. Supervisors are the primary users of the system. Thus, the system must be designed to interact with these who are not knowledgeable of personnel systems, but are knowledgeable of the jobs under their supervision. Supervisors will also have varying degrees of computer literacy, thus the system must be capable of eliciting necessary queries to users in consideration of the least knowledgeable computer user. The system must utilize a query mode that is thorough, understandable by those who use it, and tolerant of mistakes, unintentional wrong input, and inconsistent responses by users.

SYSTEM EXPANSION. As the system is designed, areas of future possible expansion will be identified to the contractor, so that the design will provide a ready ability to accept the expansion. For example, new jobs will be created in the future for which the system was not initially designed to classify. Expansion to include these new jobs must not be hindered by the system provided by the contractor. Also, new functions may be added to the system in the future, e.g. employee disciplinary actions and others. The system must not be designed in such a manner as to

hinder or prohibit future functional expansion.

The contractor will provide for participation of government project office personnel in the development of the prototype in order that these personnel become proficient at understanding the architecture of the system, its inferencing strategies, and its knowledge base. The completed system must be maintainable and expandable by government personnel.

APPENDIX L

EXECUTIVE SUMMARY

There are a number of areas in which expert systems technology can be applied to civilian personnel administration functions.

Potentially the most beneficial application of this technology is in the area of systems that can be used directly by supervisors to perform personnel functions.

If used directly by supervisors/employees, expert systems could replace personnelists who currently perform the work.

POTENTIALLY, several million dollars per year could be saved in salary costs if expert systems were designed and allowed to perform functions of personnel office employees.

In order to best assess the potentials of expert systems technology in personnel, a working prototype should be developed and tested in an operational setting.

The position management and classification function of personnel offers the best area for prototype development.

The cost of prototype development for this R&D effort will be in the neighborhood of $1.5M to $3.0M.

It is recommended an R&D project office be set-up, staffed, resourced with equipment, and charged with prototype development.

It is recommended the project be conducted as an in-house effort.

It is estimated a prototype could be built in two to three years by a staff of 7 people (knowledge workers plus support staff).

The prototype would provide all PM&C services to a test organization and operate at the expert level of accuracy.

* U.S. GOVERNMENT PRINTING OFFICE: 1985-587-155/20001

END

FILMED

12-85

DTIC